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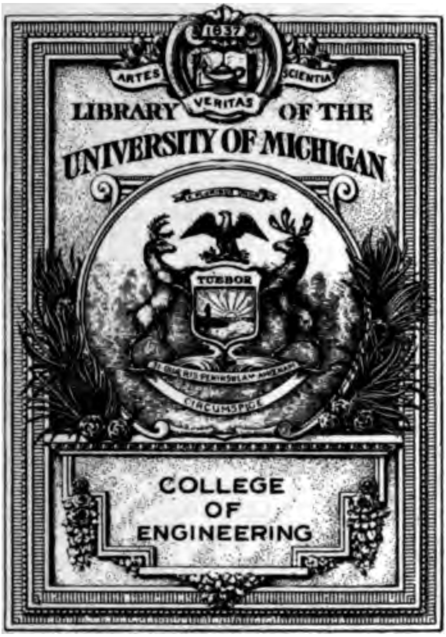
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THE BLUE BOOK of FACTS of Marine Engineering

Fourth Edition

Including new questions and problems with answers, on Engines, Boilers, Turbines, Safety-Valves, Electricity and Oil, that are required for all grades of

Marine Steam and Gas Engine License

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PREFACE

IN this, the fourth edition, you will note a change in the general arrangement of the "Blue Book." A most important feature is the marking of the questions so that you need study only those for the examination you expect to take and the new turbine, oil and electrical questions and answers.

All the new questions and problems that are required for all examinations, are included in this edition. It is written in simple language, is free from difficult mathematics and is necessary information for all grades of engineers license. It is also a valuable reference for those of you who are through with examinations.

We feel that this issue will make the "Blue Book" even more valuable than ever.

The key to the classification of the questions is on the following page. We also wish to say, that we cannot always be right in marking the questions for the different grades, as that is entirely up to the examiner, and is not within our power to regulate. While one may give you a certain question for a chief's examination, another may give you the same question for 2nd assistant, but we try to do the best we can to guide you straight. *May* we succeed.

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KEY TO QUESTIONS

C	**for Chiefs**	**D**	**for Chief & First**
1	**" First**	**E**	**" First & Second**
2	**" Second**	**F**	**" Second & Third**
3	**" Third**	**G**	**" First, Second & Third**

A for Any or All exam.

BOILER QUESTIONS AND ANSWERS

A. With what different types of boilers have you had experience?

√A. I have had experience with fire-tube and water-tube boilers, etc., etc.

G. How would you leave a boiler under banked fires, and consider it absolutely safe?

A. With sufficient water, with all valves closed, except to steam gauge, damper in stack closed, ash dampers closed and a slight space between the coal and top of furnace so it would allow a current of air to circulate over the bed of fuel, without it causing the coal to ignite and generating steam.

F. What is the most important thing to look after when a boat has been lying all night under banked fire?

A. Find the true water level, see that the water glass is in working order, take notice of the steam pressure, see that fires are all right and that the bilges are not full of water.

A. What are the duties of an Engineer at each annual inspection?

A. The duties of an Engineer at each annual inspection are to have the boilers and fire room cleaned up, boilers filled, safety valve clamped down or otherwise secured, furnace and connection doors opened to permit a thorough examination of same, to assist the inspector in his duties, to point out to him all defects coming under his observation, to answer all questions truthfully and to the best of your ability and if necessary, submit it in writing and swear to it.

3. What should an engineer do when a boiler is opened to be washed out?

A. See that boiler is thoroughly cleaned and washed out, examine closely and overhaul all valves, and examine fusible plugs.

F. Where is a fusible plug placed in a scotch boiler, why it is there, what is it for, and of what it is composed?

A. It is placed in top of combustion chamber to warn the engineer of the danger of low water. It is made of bronze with a tapered hole through center and is filled with banica tin, lead, and not more than .1 per cent zinc.

3. Does the glass on a water column show the true water level? Explain in detail.

A. No, the glass on a water column, does not show the true water-level. The water is about four inches higher in the boiler than in the glass, on account of the difference in the density. The water in glass and column, being cold, is considerably heavier and more than counterbalances *the water in* the boiler on account of its weight.

3. What would happen if the top were closed, or stopped up, or if the bottom were closed or stopped up?

A. If the top of the glass were closed, it would show full of water, if the bottom were closed or stopped up, water would remain the same in glass. In either case it is very dangerous.

D. What is priming, its effects, causes and remedy for same?

A. Priming is the carrying of water with the steam through the steam pipes to cylinder main engines and auxiliaries. And the effects are very serious at times, causing broken cylinder heads, piston rods and valve stems, sometimes causes a complete breakdown. The causes of priming sometimes are dirty water, changing from fresh to salt water, irregular firing, faulty design, too small steam space. The remedy—check fires, close all dampers, cover fires over carefully with green coal, slow engines down, open surface blow cocks and give boilers several blows from surface and bottoms to change water in the boilers, after the water has settled. Insist on regular firing, open your throttle and proceed, but do not attempt to force your engine to a speed that would cause your boilers to prime again. In some cases, it is necessary as well as prudent, to close stop valves on boilers.

3. What are the best means of stopping corrosion?

A. By cleaning boiler as often as possible and using a good compound, or Sal Soda, Astral oil or zinc plates.

3. If you were using salt feed entirely, how salty would you allow the water to become?

A. Not more than 3-32.

3. If water in boiler became very salty, what would you do to get rid of same?

A. Feed and blow.

3. How would you know water was salty in your boiler?

A. By using a Salinometer and Thermometer.

3. How salt is the water in the ocean?

A. The water in the ocean is 1-32.

3. What temperature will water boil in an open vessel?

A. Water will boil at 212° F.

F. Name the most important valves on a boiler.

A. Whistle valve, Safety valve, Blow valves, Check valves, Water glass cocks, Main stop valve, and feed line stops.

F. Name the different valves that the steam passes through on leaving boiler and passes back again to the boiler as water, after being condensed.

A. Steam passes through boiler stop valves, Main valve, Main engine valves, Air pump valves, Feed pump valves, check valves and main feed *stop valves.*

F. How would you put valves on a boiler?
A. With a Flange joint.

3. How should fires be started under a boiler?
A. Very slowly at first.

2. What is the most important thing to look for before starting fire under boiler?

A. See that you have right amount of water in boiler, see that air cock and steam gauge cock is open, all plates up tight, water glass in working order and blow valves closed.

A. When would you open your main stop on your boilers?

A. When the pressure equalizes.

E. When would you open your main stop and what particular things would you look for?

A. After cutting in boilers, I would open by pass so as to warm up line and equalize pressure, make sure throttle valve was shut, circulating pump running and then open main stop, usually about 4 hours before sailing.

3. What harm does grease do a boiler?

A. Keeps the water from coming in contact with the heated parts and may cause furnaces and crowns to bag and cause pitting.

3. What means are employed to keep it out?
A. The use of a grease extractor.

3. Can you keep it all out?
A. No.

3. If it does get in, what means would y employ?

A. I would use Sal Soda and Astral oil an clean as often as possible.

3. What may be the effect of using too much soda and Astral oil unless care is taken?

A. Too much soda and Astral oil will sometimes cause the boiler to foam and the engine takes water over.

3. Where are the effects of oil and grease first noticed?

A. Around water line, top of combustion chamber and tubes.

3. Why?

A. Oil and grease will float.

3. Why will a boiler not last forever?

A. Expansion, contraction and corrosion, poor material and workmanship.

3. For which one of these is the engineer responsible?

A. Corrosion, to a certain extent.

G. How dense would you let the water in your boiler become?

A. Not more than 2-32.

G. How would you know how dense it was?

A. By the use of a Salinometer and a Thermometer.

G. Can you mention something else that shortens the life of a boiler?

A. Galvanic action, due to various metals coming in contact with the water.

A. How would you prevent the water in your boiler becoming more dense?

A. Feed and blow.

G. How dense would you let your water get running with a jet condenser?

A. 2-32, but positively not more than 3-32.

A. What instruments are used for the purposes of testing the density of sea water, or water in boilers, also give a description and construction of each as relates to graduations, etc.?

A. The instruments used are the thermometer and salinometer. The first named instrument consists of a hollow glass tube of very small bore, with a bulb attached at the bottom of the stem filled with mercury. This tube is secured to a flat, metallic-back, graduated into degrees of temperature and adjusted to show the correct reading of the temperature of the atmosphere, or whatever liquid of which temperature is to be ascertained. The salinometer is constructed of brass or glass and consists of a stem with an oblong bulb, (the H. G. thermometer degrees are graduated from 20 degrees below zero to 224 degrees above zero) and a spherical bulb on bottom weighted with shot or sand. The instrument is then tested and the stem graduated for the different saturations from zero, or fresh water, to five thirty seconds (5-32), which represents 1 part salt to 32 parts water for each thirty second (32) as shown on the instrument or five ounces of salt to the gallon.

A. State how you would make a salinometer, if there were none aboard ship, or at least how those already constructed are graduated?

A. Take a bottle, put weight inside and cork. Then take a bucket of fresh water, heat to 200° F. Place bottle in and mark at water level. Take one gallon of sea water and heat to 200° F. Place bottle in again and mark at water level 1-32. Take two gallons of sea water, boil down to one gallon. Heat to 200° F., place bottle in again and mark at water level 2-32. Then take three gallons of sea water and boil down to one gallon and again heat to 200° F. and mark bottle at water lever 3-32, then mark between 2-32 and 3-32 limit blow.

F. How much water did you carry over the back connections in the last vessel you were employed on?

A. Answer according to what you did carry.

G. What is the temperature of steam at 180 lbs.?

A. About 373°.

F. Name the different kinds of boiler stays?

A. Screw, socket, crowfoot and tube stays.

F. What four causes will make a boiler plate bag over the fire?

A. Low water, grease, mud and scale.

2. If you were to examine a boiler on the inside, for what principle defect would you look?

A. I would give it a good test with a hammer, look for corrosion, pitting, scale, broken stay rods and stay bolts, look at braces, rivets, cracks around tube sheets and heads and see if fusible plugs are in proper place and condition.

D. How would you take saturations of boilers?

A. With the use of a salinometer and a thermometer, I would draw the water from the boiler into the salinometer pot, place thermometer in water to take the temperature, as all salinometers are graduated to 190°-200° and 210°. I would heat water to either of the three degrees, then place salinometer in water and after wetting, take reading at water level.

G. How much salt in the water of the Atlantic coast?

A. 1-32.

F. What is mechanical circulation?

A. Circulating the water in the boiler with a pump or the use of a hydrokineter.

2. What will happen if the water in the boiler becomes too salty?

A. Rapid accumulation of scale, priming and *perhaps* explosion by overheating sheets.

F. What are the effects of scale in a boiler?

A. Keeps the water from coming in contac with the heated surfaces and causes the plate to bag or burn. May cause an explosion.

F. What are the effects of oil in a boiler?

A. Oil forms a coating around top of water-line, top of tubes and crown sheet, also keeps water from coming in contact with heated surface and causes pitting in the boiler.

F. How would you effect a remedy for this?

A. Use Astral oil and Sal soda to cut greases and scale, clean boiler and use a grease extractor.

E. Describe the different methods of fastening the main stays in a boiler?

A. Screwed in with a nut on each side of sheet or screwed in with a nut on one side and riveted on the other or also with forked ends and riveted to the head.

G. Where are the thin plates found in a boiler?

A. Around combustion chambers, crown sheets and fire box on fire line.

E. What causes cracked tube sheets? Where do they generally crack and how are they repaired?

A. Defects in material and construction, excessive strains, uneven expansion and contraction. They show up around rivets, flanged corners and between tubes. Drill holes in each end of crack, *calk same and put* on patch.

A. What causes foaming and how would you prevent it?

A. Foaming may be caused from mud or dirt which forms a scum on the surface of water, irregular firing, feeding or starting the engine too suddenly. The water may be carried over and cause the cylinder head to crack or blow out. Slow engine down, blow boiler surface and bottom and wash out as soon as possible.

F. What is circulation?

A. Circulation in a boiler is the rising of the heated water, owing to its being lighter, thus displacing the cooler water on the surface, which falls to replace it, and then in return rises. This action goes on continuously during the generation of steam.

F. Do you know of any pump that has no valve?

A. Yes, a centrifugal pump has no valve.

F. Into how many forms are water-tube boilers generally divided? Name them.

A. Water-tube boilers are divided into two forms, by virtue of position of tubes—vertical tubes and horizontal tubes.

E. If a small hole appeared in one of the furnaces over the fire in your boiler and you had no taps on board, what would you do?

A. I would place a rivet in the hole.

E. In the above question, the boiler would to be emptied before it could be repaired. would you fill it up again, having no stea work the pump and no hand pump on board?

A. I would open the bottom blow and valv ship side, let the sea water back in same, get steam and blow boiler down several tim get rid of the salt water.

3. What is a boiler?

A. A boiler is an apparatus for conver water into steam by the application of heat.

✓ E. Should the feed water of a scotch b be fed into the steam or water space?

A. Into the water space, below the water if fed into the steam space the chances are the greater part will be carried over into engine, causing great trouble. Practice is by means settled as to the exact point at which feed should be introduced.

C. Why is drilling better than punching making holes in a boiler?

A. Because the drilling does not so seve distort and weaken the metal in the immed neighborhood of the hole. With punching thin section of metal about the hole is so seve strained that its strength and toughness are v much reduced. Again, drilled holes are m easily placed accurately than are punched ho which tend to make a much better fit in a riv joint. The drilled holes are more expensive for some classes of work they are required by the specifications.

C. Does the wetting down of boiler coal lead to a saving of any sort, as regards fuel consumption?

A. No. The addition of water means a distinct loss, for in becoming vapor this water absorbs heat, which is carried off in the products of combustion. To put the case in another way, water can not in any way be used for fuel or for a substitute for fuel. As a matter of fact, an indirect influence may be felt, in that the wetting may have an effect upon the caking of bituminous coal, as well as upon the formation of clinkers. Again with wet coal, there would be a smaller amount of coal dust lost by being blown up the funnel in a lively draft. Again, the formation of hydrogen or of water gas, may distribute the combustion differently through the furnace and combustion chamber and thus lead to a better absorption of heat than with the dry fuel. These indirect advantages will not offset the direct loss.

E. How do you find the proper size of safet valves for a boiler?

A. Three square feet of grate surface is allowed for one inch area of springloaded valves, or two square feet of grate surface to one inch area of common lever valves.

F. How often should boilers be thoroughly examined and tested?

A. Twice a year.

E. Describe the single action plunger pump; how it gets and discharges its water?

A. The plunger displaces the air in the water pipe, causing a vacuum which is filled by the atmosphere forcing the water therein; the receiving valve closes and the plunger forces the water through the discharge valve.

✓ G. Where is the best place to enter the boiler with the feed water?

A. Below the water level, but so that the cold water cannot strike hot places. If injector is used this is not absolutely necessary, as feed water is always hot.

3. If you found a thin plate, what would you do?

A. Put a patch on it.

3. Would you put it on the inside or outside?

A. On the inside.

3. Why would you put it on the inside?

A. Because the action that has weakened the plate will then set on the patch, and when this is worn it can be replaced.

F. If you found several thin places, what would you do?

A. Patch each and reduce the pressure.

2. What would you do if you found a plate on the bottom buckled?

A. *Put a stay* through center of buckle.

2. If the safety-valve was stuck, how would you relieve the pressure on the boiler, if the steam were up and could not make its escape?

A. Work the steam off with engine, after covering fires with coal or ashes and when the boiler is sufficiently cool, put safety valve in working order.

F. What would you do if you should find your water gone from sight very suddenly?

A. Draw the fires and cool off as quickly as possible. Do not open or close any outlets of steam, when your water is out of sight.

E. What precautions should you take to blow down a part of the water in your boiler, while running with a good fire?

A. Never leave the blow-off valve and watch the water level.

E. How much water would you blow off at once, while running.

A. I would not blow off more than one gauge of water at a time while running.

E. In your opinion, what are the greatest causes of boiler explosions?

A. Ignorance and neglect are the greatest causes of boiler explosions.

E. What is meant by ductility of a boiler plate?

A. The ductility of a boiler plate is the percentage of stretching which the material will stand before breaking. In testing boiler plate it should have sufficient elasticity to stretch about twenty-five per cent.

F. What are stay tubes?

A. Stay tubes are boiler tubes of a stouter description used for strengthening the tube plates.

F. Which is the better, single or double riveting?

A. Double riveting is from sixteen to twenty per cent. stronger than single.

A. What is the object of a safety valve on a boiler?

A. To relieve pressure.

G. What is the use of a check-valve on a boiler?

A. To prevent the water from running back into the pump or injector which feeds the boiler.

G. Do you think a manhole in the shell on top of a boiler weakens it any?

A. Yes, to a certain extent.

3. What effect has cold water on hot boiler plates?

A. It will fracture them.

E. Where should the gauge-cock be located?

A. The lowest gauge-cock ought to be placed not less than 4 inches above the top row of flues, *tubes, or combustion* chamber.

F. What parts of a marine tubular boiler are first injured by shortness of water?

A. The portions of a marine tubular boiler first affected by shortness of water are, the combustion chamber tops.

E. How many bottom blow-off cocks are generally fitted to each boiler, and why are they so fitted?

A. One bottom blow-off cock is usually fitted to the after end of the bottom of the shells of boilers, it again being connected by a copper pipe to a cock or valve on the ship's bottom. These cocks are so fitted, in order that the densest water and all deposits can be blown out of the boiler at its lowest point, when the practice of blowing down is resorted to.

D. Why are blow-off cocks sometimes fitted with a spanner guard?

A. The object of a spanner guard, is to do away with the posibility of unshipping the box spanner or key without closing the blow-off cock, as it is only when the cock is perfectly closed that the tongue on the key and the recess in the guard correspond.

D. What is a dead weight safety-valve?

A. A dead weight safety-valve consists of a valve loaded directly with cylindrical iron or lead weights, weighing in pounds an amount equal to the area of the valve, multiplied by the steam pressure required in pounds above the *atmosphere.* Thus, a four-inch valve has 12.5

square inches per area, and is to be loaded to sixty pounds per square inch; the dead weight required to be placed directly on this valve will be 12.5 times sixty or seven hundred and fifty pounds.

E. Why is a small cock sometimes put on the pipe leading to a steam gauge? Where should it be placed? What error might be made by omitting to use it?

A. A small drain cock should be fitted to the leg of the syphon of a steam gauge leading to the boiler, at a level with the highest point the water can rise in the other leg; otherwise an increase of pressure will be indicated, due to the head of water which would otherwise collect in the boiler leg of the syphon.

G. Where is it that boiler tubes leak?

A. Boiler tubes generally leak at the combustion chamber end.

A. What is a hydrokineter and for what is it used?

A. A hydrokineter is an appliance used to force the circulation of the water in a boiler, before steam is up. It consists of a steam jet and a series of nozzles with their rear frames perforated for the passage of water, the steam being furnished by another boiler. The device is placed near the bottom of the boiler, where the water would naturally tend to remain cold for a considerable period after the fires are ed. It serves to drive out this water into a on of the boiler, where it will be more di- y in contact with the surfaces heated by the ucts of combustion from the furnaces. In neantime, heated water gradually comes down place that which is removed, and thus the lation is established.

What is the source of all power?

The sun.

How much grate surface do boiler makers v per horse power?

About two-thirds of a square foot.

Of what use is a mud drum on a boiler?

A mud drum is used for collecting all the ment in the boiler.

How often should it be blown out?

Three or four times a day.

How many valves are there in a common nger force pump?

Two or more, a receiving and discharge e.

How are they located?

One on the suction side, the other on the charge.

Why do injectors sometimes refuse to k?

Leak in suction, leak around the plunger leaky check valve, or valves out of order, or lift too long.

3. When should a boiler be blown out?

A. After it is colled off, never while hot.

3. If water is allowed to get too high what will result?

A. Cause priming, perhaps cause breaking of cylinder covers or heads.

C. What are the special disadvantages of water tube boilers?

A. Water-tube boilers are very sensitive with regard to quality of feed water and the steadiness with which it is supplied. The quantity of water contained within the boiler while in operation is so relatively small that any irregularity in supply might well result in a lowering of the water level to such a point as to introduce elements of danger. For this same reason of small water space, rapid changes in demands for steam from the boiler make necessary constant watchfulness with regard to the water level. Due to similar causes, the boiler is quite likely to prime. Structurally, the boilers are made up of a large number of small parts, thus introducing complications as compared with cylindrical boliers. Many of the tube joints are accessible only when the boiler is not under steam. On account of the great extent of surface in contact with the fire, radiation loss is liable to be greater in water tube boilers than in those of the fire-tube

✓ C. How is the pitch of rivets in boiler seams determined?

A. The diameter of rivets used comes from a consideration of the relative strength of the rivets against shearing off to the tensile strength of the part of the plate between rivet holes. General practice makes the diameter of the rivet about 1.8 times the thickness of the plate, and the pitch of the rivets about 2.5 times the diameter for single riveting, and about 3.5 times the diameter for double riveting.

A. What is the horsepower of a boiler?

A. It is the evaporation of 30 pounds of feed water, of 100° temperature to a gauge pressure of 70 pounds.

F. Why is a Salinometer usually marked at 200°?

A. Because when the water has been drawn off from the boiler, and its action has ceased, its temperature will be about 200°, so that if we have no Thermometer on board, we will still be able to use the Salinometer.

G. What is the boiling point of fresh water?

A. The boiling point of fresh water is 212°.

G. What is a gusset stay?

A. A gusset stay is merely a piece of plate iron secured to the boiler front or back, near the *top* or the bottom.

G. Upon what does the pressure on a cylindrical boiler depend?

A. Upon the tensile strength per square inch of the plate, the thickness of the plate, and the diameter of the boiler.

E. Where is the greatest pressure in a flat-bottomed boiler and why?

A. On the bottom, because there is the steam pressure plus the water pressure.

E. Which is the stronger furnace tube, a square one or a round one and why?

A. The round one, because the stress on the tube is mostly a collapsing stress, and if the tube is made a perfect circle in section, it will be better able to resist this stress than with a section of any other shape.

E. How are combustion chamber tops supported?

A. Two methods are in common use, flat tops with dogs across and two or more stays down, or a curved top supported by a screwed stay, or a palm stay.

E. What should the Salinometer stand at in a common jet?

A. Eight to ten ounces.

E. What is that in grade of salt?

A. 1½-32, 2-32.

G. When you want to find the height of your water by the test cock, which would you open first and what should come out?

A. I would open the bottom one first, water should come out.

E. In a cylindrical boiler where a large nut and washer is used both inside and outside, why is the outside washer larger than the inside washer?

A. So as to hold better the back and front ends together.

F. What is the temperature of water in hotwell?

A. From 100° to 130°.

G. Why will a pump not lift hot water?

A. A pump will not lift hot water, because the vapor arising from it breaks the suction or vacuum.

F. If the scale on your thermometer became broken, how would you make a new and graduate another one?

A. Water freezes at 32°, then mark Fahrenheit, and boils at 212° F. Mark there, then space off with division.

C. What care should be taken of fusible plugs to prevent them from fusing?

A. Never allow the water to get below the level of the top of the combustion chamber, also see that the plug is kept clean and that the top of combustion chamber, particularly around plug, is also kept clean, to allow the water to act on both the plug and surroundings.

C. Why are boilers provided with blow off cocks on ship side as well as on the shell of boiler?

A. If after blowing your boiler, you found the valve on the shell of your boiler would not seat, you could close the one on the ship's side and run your boilers at the proper level until you had time to blow boiler down and repair same. If on the other hand, while blowing the boiler, your blow pipe should split, the valve on the ship side would prevent the sea water from coming in, while the valve on shell would prevent the water from leaving the boilers.

2. What is initial pressure?

A. Initial pressure is the pressure at the beginning of the stroke.

A. What is meant by the density of water?

A. The soluble material it contains. The density of sea water is 1-32 as marked on the salinometer and means that there is one part of solid matter, thirty-two parts water.

C. What causes furnace crowns and tops of combustion chambers to come down?

A. If of suitable material and sufficient *strength, of proper* design and workmanship, the cause is the plates become overheated by water not acting on the plates, being prevented by scale or grease, causing them to weaken under the increased temperature.

2. When would you open the stop valves on each boiler, if you were going to get up steam?

A. I would open them when I had three or four pounds of steam on each boiler and keep them as uniform as possible.

F. Which is the most dangerous to operate, a boiler with dense water carrying 50 lbs. steam, or one carrying 200 lbs. and why?

A. A boiler with dense water carrying 200 lbs. of steam is decidedly more dangerous to operate than one carrying 50 lbs. steam, for the precipitation of the soluble matter held in suspension in the water is greater at 200 lbs. than at 50 lbs. pressure.

F. Under which condition would you find the most scale in a boiler, under forced or natural draft?

A. Under forced draft on account of greater heat and evaporation.

A. How many ounces of salt is contained in 16 lbs. of sea water, where the density is 1-32?

A. To find how much salt there is contained in any given number of pounds of sea water, where *the density* is 1-32, multiply the number of pounds of water given, by the number of ounces in a pound and divide by the density, so in 16 lbs. of sea water you have, 16 x 16 ÷ 1-32 = 8 ounces.

3. What does fresh water contain?

A. Fresh water contains, sulphite of lime, carbonate of lime, salts of iron, magnesia, silica and animal matter.

3. What does salt water contain?

A. Salt water contains, chloride of sodium, murate of magnesia, sulphate of magnesia and sulphate of lime.

F. What precaution should be observed when turning steam into a line of cold pipe?

A. The precautions taken in turning steam into a line of cold pipe would be, to see that all drains on branches were open to drain the water of condensation; open the steam valve very slowly to warm up gradually, to prevent water hammer, and injury to joints and pipes through unequal expansion.

D. What hydrostatic pressure of water would be put on a boiler for inspection by the U. S. Government?

A. 150 lbs. per square inch for every 100 lbs. per inch of steam pressure allowed.

FUEL QUESTIONS AND ANSWERS

Q. Name two kinds of oil used for fuel and explain them.

A. Paraffin Base oil and Asphaltum Base oil. Paraffin base means that when all the other products are extracted that which remains is a Paraffin Base. The same for Asphaltum base which, however, is a heavier oil than Paraffin. Paraffin oil is found around Pennsylvania and vicinity, while Asphaltum oil comes from Texas and Mexico.

Q. What are some of the advantages of oil burning?

A. Cleaner than coal, increased efficiency, requires less space. Double bottoms and other spaces, which are useless for bunkering coal, can be utilized. Less men needed in the fireroom.

Q. What is meant by the "Flash Point" of oil?

A. It is the temperature at which the oil will give off an inflammable gas.

Q. What is the "Fire Point" of oil?

A. It is the point at which the oil will support combustion.

Q. What are the requirements for the combustion of fuel oil?

A. There are three things necessary for the perfect combustion of fuel oil; they are atomization, fuel gases to be at ignition temperature, quantity and velocity of air.

Q. What is Atomization?

A. The breaking up of fuel oil into minute particles by mechanical means.

Q. Give the three methods of Atomization.

A. Air, steam and mechanical.

Q. Which method is used in marine work?

A. The mechanical means of Atomization is generally used and air to a limited extent.

Q. What does heavy black smoke issuing from the stack indicate?

A. This condition indicates that poor combustion is taking place. Consequently some of the heat which should be heating the water in the boiler is being wasted.

Q. Why are Stack temperatures taken?

A. They are taken to correctly gauge the combustion conditions.

Q. What smoke conditions indicate ideal combustion?

A. A light, hazy, brown smoke issuing from the stack would indicate that ideal combustion is *taking place.*

ENGINE QUESTIONS AND ANSWERS

A. What are the duties of an engineer?

A. The duties of an engineer, are to familiarize himself with his plant, keep the boilers in good condition, have proper amount of water at all times and see that all machinery is in good order.

A. Describe the different types of engines with which you have had experience.

A. Give descriptions according to your experience.

F. Describe in detail how you would lay a boat up for the night.

A. I would close all overboard valves, reduce steam pressure on boiler, bank fires, fill boiler with water, close water glass cocks, see that main stop is closed and all other valves that should be closed.

E. What is the effect of linking up an engine?

A. To save steam and coal and get the full benefit of expansion.

C. If you were out and your high pressure eccentric broke, how would you fix it so you could come in under your own steam?

A. If Stevenson link motion, I would take backing eccentric and use for go ahead; hang up backing end and make fast.

C. If your low power cylinder head carried away, what would you do?

A. If it were not too badly damaged, I would try to effect repairs by patching same, or make temporary repairs out of wood and iron, if there were enough suitable material on board to make a head until ship arrived in port. In the event of not having material, I would block steam ports after removing the valve and proceed compound after removing connecting rod, piston rings and lower piston in bottom of cylinder.

F. What particular things would you look for, when going on watch?

A. Make sure of water in boiler, examine engine and see that machinery is running O. K. and bilges are as near dry as possible.

F. Suppose your eccentric slipped and you had no marks to set it by, how could you set it, so the engine would run without taking the steam cover off?

A. I would place engine on dead center and if go ahead eccentric slipped, I would put engine in full back-up motion, make a mark at valve stem gland, then throw the engine in full go-ahead motion, move slipped eccentric around until the marks come the same as before, make *eccentric fast, put* engine opposite center, put her in back-up motion, mark on valve stem as before, put engine in go-ahead motion, see if mark comes the same. If so, make eccentric good and fast, or you can try with indicator card.

E. How would the valve of an engine have to be constructed, so that the eccentric would be placed 90° ahead of the crank?

A. The valve would have to be constructed without lap or lead.

F. How should valves be screwed on pipes, so that they could be packed with steam on?

A. So that the pressure will come under the seat.

E. How should you open a valve to admit steam in a cold line? For instance, the main steam pipe.

A. Open by-pass slowly if any; if not, open main valve very slowly.

G. What is lead? What is exhaust lap? What is steam lap?

A. Lead is the amount the valve is open, when the engine is in center. Exhaust lap and steam lap is the amount that the valve extends over the ports at mid travel.

E. What particular things are to be looked for in regard to vessel and machinery, before turning *engine over?*

A. See that ship is made fast to the dock. Feed stops and check valves open; suction and discharge valves from pumps open; jacking gear out and have engine all clear.

E. Suppose you had a non-condensing engine and you wanted to turn it into a condensing engine? What extra pump or pumps would you need for each of the different types of condensers?

A. For a jet condenser, I would need an air pump. For a surface condenser, I would want a circulating and an air pump.

E. How many valves or sets of valves, are in a common air pump? A feed pump or a bilge pump?

A. An air pump has three, namely, foot, bucket and head valves. A feed pump has two, a suction and discharge.

E. Could the pump work without any of these valves?

A. An air pump could work without the foot valve.

E. How could you tell, if your crank shaft were out of line with your line shaft?

A. By taking out the coupling bolts.

E. Suppose you were out and a tube split. How could you fix it, if you had no proper stopper rod or caps?

A. I would make a wooden plug to fit the tube, cut in the center like a spool.

2. If your vacuum began to fall where would you look for the trouble?

A. I would see if the circulating pump had stopped. Examine air pump, and see if valve were open to condenser and examine L piston.

E. What is a separate expansion valve, and what effect has it on starting or reversing engines?

A. A separate expansion valve is an arrangement of two valves attached to a valve stem with right and left threads connected to suitable block nuts, that causes the valve to expand and come closer together at the will of the Engineer, by manipulating the gear suitably arranged for the work required and regulate the point of cut off of steam at any given point, at will of the Engineer. It has a deterent effect on starting the engine or reversing engine, if the cut off is set to cut off at a short point of cut off and should be taken off when handling the engine.

C. What is meant by expansion?

A. The distance the piston moves, after the supply of steam to the cylinder has been cut off and before release takes place.

C. If the joint on your Kingston valve blew out, how could you replace it?

A. I would make a strongback over valve, slack off nuts, slack bonnet back, in the meantime holding valve with strongback and put in dove-tail joint.

E. What great danger would arise if your condenser started to leak very bad?

A. It would cause the boilers to become salty and the plates to become overheated and may cause an explosion.

E. When vessel is clear, what is to be looked for when changing from atmosphere to condenser?

A. Try not to lose vacuum, but this is usually done before ship leaves.

D. Two vessels left port at the same time, neither had tanks or evaporators, but one had jet condenser, the other a surface condenser, which would salt up first, and why?

A. The one using jet condenser, as the condensed water mixes with sea water.

D. If a plug blew out in a boiler having 4 or 6 furnaces, what would you do to save boiler and make repairs to get under way in the shortest time?

A. Put plenty of feed water on, haul your fires, work engine strong to relieve pressure. When fire is out, cut out boilers. If plugs are screwed in from fire side, I would renew same, if from water side tap out for a plug to fit.

D. If you found valve broken, what would you do in the shortest time?

A. Remove valve and run compound, if H. P. would reduce pressure.

D. If your crosshead or fork end of connecting rod on forward end broke, what would you do in regard to crosshead connecting rod and valve?

A. I would remove valve and connecting rod; drop piston to bottom of cylinder, reduce pressure and proceed to compound.

D. If the aft journal broke through the bearing, what is the best thing you could to in making repairs in the shortest time?

A. Slow down and proceed under reduced speed.

D. Why are piston valves used in one part of *an engine* and slide valves in another? What is the difference in them in regards to lap, lead and setting?

A. Piston valves are more evenly balanced than slide valves. Slide valves are used in parts of the engine to economize in space. Steam is taken on both ends and exhaust in the middle, and leads the crank, plus lap and lead, on outside. A piston valve takes steam in the middle and exhausts on both ends. The valve follows the crank less lap and lead and lap and lead on inside.

D. How would you change the total lead with link motion? How would you give the valve more lead on one end than on the other?

A. Advance eccentric on shaft for total lead. To give more on one end than the other, put washer under or take out, as the case may be, on the other end.

D. What causes most trouble with pumps, either independent or connected, when water supply is irregular?

A. An irregular supply of water causes pumps to become air-bound.

D. Can you suggest a remedy?

A. Use a float to regulate the supply of steam, according to the water supply.

E. When water is heated before it goes to the feed pump, why is heater placed higher than the pump?

A. The heater is placed higher than the pump, because a pump will not lift hot water.

3. Make a sketch of an indicator card, showing lead, compression, expansion and release line.

A. Draw card plainly.

D. What causes expansion?

A. Sudden release or cut-off of steam in the cylinder, as the steam follows the piston for a part of its stroke, the balance of the stroke is caused by the expansion of steam.

G. Can the lead of a valve be found by a cord?

A. Yes.

E. For what things in particular would you look when running a condenser in a sea way?

A. Keep engine from racing and see that boilers do not get over 2/32 salt.

D. Of what must you be careful when standing by and working into port?

A. You must be careful and see that water does not back up into low pressure engine.

1. If a strong wind shifts from the head or bow to the quarter, and sail is made fast, will the engine turn faster or slower; use more or less coal? Does cut-off remain the same?

A. The engine turns faster; uses less coal.

D. If your cuts were set, so that each engine does the same amount of work, and you open up the high pressure a little, which engine does the most work?

A. The high pressure engine.

1. Why is metallic packing used in some parts of an engine and soft packing in others?

A. Metallic packing is better for high pressure, and soft packing is better for low.

E. What is the difference between a single and a compound engine?

A. In a single engine the steam is expanded once and in a compound engine the steam is expanded twice.

E. What is the difference between a single and double acting pump?

A. A single acting pump lifts water on the up stroke and pumps it out on the down stroke. A double acting pump, pumps water both ways.

F. Does a pump suck water?

A. No. The piston or plunger displaces the air and the atmospheric pressure forces the water through the pump.

E. How would you line up an engine?

A. By taking off cylinder head, remove piston, *crosshead and* connecting rod. Next, pass a line through center of cylinder and stuffing box. Put engine on center. Off line comes to center of crank pin. Engine is in line. Next, see if line is level.

D. How would you set a slide valve?

A. Put engine on top center. Get lead. Then put engine on bottom center and get lead and then adjust lead to suit engineer. Most engineers give more lead on bottom.

D. What is a counterbore?

A. About one per cent of the top of the cylinder is tapered and is called the counterbore. It allows the piston and rings to slide into cylinder with ease, so as not to wear a shoulder in the cylinder.

D. What percautions should an engineer take, when it is necessary to stop with heavy fires?

A. An engineer should close dampers, put on injector or pump, and if a bleeder is attached, use it.

E. Of what use is the indicator?

A. The indicator is used to determine the indicated power developed by an engine to serve as a guide in setting valves and showing the action of the steam in the cylinder.

1. How would you increase the power of an engine?

A. To increase the power of an engine, increase the speed; or get higher pressure of steam; use less expansion.

F. What is steam?

A. Steam is an invisible, elastic gas, generated from water by the application of heat.

F. What is a vacuum?

A. A vacuum is a space void of all presure.

F. What is the benefit of a vacuum?

A. The benefit of a vacuum is that it destroys the back pressure, and increases the power without increasing the pressure or size of cylinder, as 1" of vacuum is equivalent to ½ lb. of pressure and makes a more economical arrangement on this account.

F. How do you maintain a vacuum?

A. A vacuum is maintained by the steam used, being constantly condensed by the cold water or cold tubes, and the air pump is constantly clearing the condenser out.

E. What do you understand by lead on an engine's valve?

A. Lead on a valve is the admission of steam into the cylinder, before the piston completes its stroke.

D. What is the clearance of an engine, as the term is applied at the present time?

A. Clearance is the space between the cylinder *head and the piston* head with the ports included.

D. What is the dead center of an engine?

A. The dead center of an engine is the point where the crank and the piston rod are in the same right line.

D. How can an engineer tell from an indicator diagram, whether the piston or valves are leaking?

A. Leaky steam valves will cause the expansion curve to become convex; that is, it will not follow hyperbolic expansion and will also show increased back pressure. But, if the exhaust valves leak also, one may offset the other, and the indicator diagram would show no leak. A leaky piston can be detected by a rapid falling of the pressure on the expansion curve immediately after the point of cut-off. It will also show increased back pressure. A falling in pressure, in the upper portion of the compression curve, shows a leak in the exhaust valve.

D. An air valve is sometimes fitted to a circulating reciprocating pump; what purpose does it serve?

A. An air valve is sometimes fitted to a circulating reciprocating pump, so that the air that is admitted will tend to soften the otherwise solid resistance offered by the water.

E. What is a condenser as applied to an engine?

A. As applied to an engine, the condenser is a part of the low pressure engine, and is a receptacle into which the exhaust enters and is there condensed.

D. What is the explanation of the economy of the surface condenser?

A. The economy of a surface condenser lies in the fact, that the feed water is fresh if the condenser is tight, and is returned to the boiler at a higher temperature than in a common jet. This does away with the loss of fuel through not having to continuously keep the scum and blow off going, as in a common engine, to freshen the water and so prevent salting the boiler.

1. Does a cylinder escape valve, self-acting, allow all the water to escape; if not, how much is left in the cylinder?

A. A cylinder escape valve will clear the cylinder of all the water in it, except the quantity due to the clearance between the top and bottom of piston, and the cylinder cover or end, as the case may be.

E. What parts of an engine are sometimes made of wrought iron?

A. Wrought iron is sometimes used in making link-motion eccentric rods, straps, valve spindles and connecting rods.

E. Where is white metal sometimes used?

A. White metal is sometimes used in the bearing, cross-head and crank pin brasses.

E. What is the position of the sheave in regards to the crank?

A. At right angles or 90°, ahead or in back.

D. Why do high-speed engines have a short stroke, as compared with the diameter of the piston?

A. Because they can be run at a high rotative speed without exceeding the permissible limit of piston speed. A disadvantage of the type is the comparatively large ratio the clearance bears to the volume of piston displacement. An advantage is the high average temperature of the parts exposed to steam, resulting to lower condensation wastes.

✓ 2. What is the proportion of heating surface to grate surface?

A. 40 to 44 square feet for heating surface, to one square foot of grate surface.

E. What is the throw of the eccentric?

A. The throw of the eccentric is the distance between the center of the bore and the center of the eccentric.

D. What are some of the minor defects that may cause stoppage at sea?

A. Besides actual breakdowns, there are a *number of min*or defects that might cause stoppage at sea, namely—hot bearings, loss of vacuum, leaky condenser, division plate in condenser broken, leak between low-pressure cylinder and condenser.

E. What bearings are most liable to become hot?

A. The main shaft bearings, crank pins and thrust bearings are most liable to become hot.

E. Give several reasons that might cause a crankshaft to break.

A. Different reasons for a broken crankshaft are, engine being out of line, hot bearings, the use of salt water on journals and racing.

1. What are several kinds of reducing motions, as used in indicator practice?

A. Several kinds of reducing motions, as used in indicator practice, are: pantograph, the pendulum, the brumbo pulley and the reducing wheel.

1. What causes coupling bolts to break and how would you make a repair?

A. The usual cause for the breaking of coupling bolt is due to the shaft being out of line. In making repairs, if they should all break at one flange and no spare ones are on board, I would take one bolt from all of the other couplings until I had enough to repair the damage.

D. If the air pump breaks down, what pump in some boats, can be made to do the work?

A. If the air pump breaks down, the circulating pump in some boats may be made to do the work. However, this depends on whether the circulating pump forces the water through the condenser or draws the water through. If the pump forces the water through the tubes, great care should be exercised to see that none of the condensing water enters the low pressure cylinder. But if the circulating pump draws water through the condenser, then by taking some of the tubes out, the water may flow on both sides of the condenser and will be taken away by the circulating pump.

D. What causes broken eccentric strap?

A. A broken eccentric strap may be due to excessive friction of the slide valve or it may be that the strap has been worn so that it has become too weak to perform its work.

D. How would you repair a broken valve bridge?

A. Should it happen that one of the bridges between the steam and the exhaust ports breaks or gives away, it may sometimes be repaired by boring holes in the broken part and fixing it in its place again by screwed pins, or if this is not practical a piece of any suitable material, may be fitted in and secured in a like manner.

D. What are the principal causes of steam pipe failures?

A. The principle causes are: accumulation of water in the pipes, producing water hammer, insufficient expansion in the pipes to allow for the movement of machinery and boilers, and defective material.

E. What necessary precautions should be taken in case of defective steam pipes?

A. In case of a defective steam pipe, the first duty is to shut off the escape of steam. The next duty must be to safeguard the boiler, so that the pressure will not rise when the valves are closed, and also that there shall be no low water due to the large amount of escaped steam in the boilers.

C. What causes cracked furnace crowns?

A. Cracked furnace crowns may be due to an accumulation of scale in the bottom of the corrugation, most usual in corrugated furnaces and are of frequent occurrence. One way of repairing this defect is to bore a hole on each end of, but well clear of the crack. Tap them and insert plugs, riveting them over, to prevent the crack from spreading. After the plugs are inserted, the crack should then be tightly caulked over.

E. How would you repair a broken eccentric *sheave?*

A. In the case of a broken eccentric sheave a repair may generally be effected by boring and tapping a number of holes in the sheave and securing a stout bolt on the outside.

E. How do you make the vacuum in a jet condensing engine?

A. Open the blow-through valve or cock, and the steam in its passage through will blow out all air and water in the condenser, at the same time warm her up. When steam issues hot out of the sniffling valve, shut blow-through valve, and open the injection cocks, and the cold water scattered by the rose or dash plate, mixing with the steam condenses it and forms a vacuum. When the gauge shows a sufficient vacuum, shut the injection cocks to prevent the condenser filling.

E. Why do you condense the steam?

A. To get rid of it when it has done its work, thus making a vacuum and so destroying the back pressure that would otherwise be on the piston, and to get more useful work out of the steam.

2. Where is the bilge injection attached to a surface condenser?

A. It is not attached to a surface condenser, it is attached to the suction of the circulator.

E. What is the object of a crank?

A. To connect a straight line motion into a *circular one.*

1. Does the crank pin travel on equal parts of its circle while the piston travels over equal parts of its stroke?

A. No, it does not.

1. How is the valve made to cut the steam off at any given part of the stroke?

A. By increasing or decreasing the width of the face of the valve.

1. Why do you not use plain plates in a surface condenser instead of tubes?

A. Because you will get more cooling surface with tubes.

E. How could you tell if the condenser tubes were leaking?

A. By testing the water brought up by the air pump.

E. How could you find out the leak?

A. By stopping and filling the condenser with water

E. Could a surface condenser be turned into a common jet one?

A. Yes, by drawing some of the tubes.

E. What is the temperature of the feed water in a jet condenser and a surface condenser?

A. About 100° in a jet condenser, and about 120° in a surface condenser.

E. What are centrifugal pumps used for?

A. Mainly circulating where low pressures are required and of late also for feed pumps.

3. How many valves has a centrifugal pump?

A. A centrifugal pump has no valves.

3. How many valves has a double acting pump?

A. A double acting pump has four valves.

1. How would you find out if your screw shaft were true?

A. I would take the bolts out of the couplings, and see if the couplings open at the top.

E. How do you know when there is too much injection?

A. By the cooling of the condenser, and the rising of the gauge.

E. How do you know when there is not enough injection?

A. By the heating of the condenser and the falling of the gauge.

E. In a jet condenser, if the injection were not shut off when the engines are stopped, what would happen?

A. It would fill the condenser with water, and *in some* engines find its way into the cylinder.

E. If water did get into the cylinder what would be the result?

A. It would split the piston, or knock out the cylinder cover.

E. What are the effective heating surfaces of a marine boiler?

A. The effective heating surface of a marine boiler it that portion exposed to the heat of the fire, and situated above the fire bars. Horizontal surface is the most effective, vertical having only half the value of horizontal.

A. What is the temperature of melting ice?

A. 32°.

A. What is the temperature of steam at 60 lbs. pressure by steam gauge?

A. 307°.

G. What is the temperature of steam at 100 lbs.?

A. 328°.

G. What is the temperature of steam at 150 lbs.?

A. 358°.

1. What is meant by a non-return valve?

A. A non-return valve is one which will open under pressure in one direction and will close in *the opposite* direction under a back pressure.

E. What is the pitch of a propeller?

A. The distance it would advance in a solid substance in one revolution.

E. What is a radically increased pitch?

A. A blade whose pitch increases toward the tip, the decrease at the boss is usually 10 per cent., on the calculated pitch given at the tip.

E. Does the propeller drive the ship ahead exactly the amount of pitch for one revolution?

A. No.

E. How is some of the pitch lost?

A. By slip.

E. How many kinds of slip are there?

A. Two, real and apparent, the latter being sub-divided into positive and negative.

E. Is real slip the same as apparent?

A. No.

D. What is the measure of a horse-power? How is indicated horse-power ascertained?

A. A horse-power is 33,000 lbs. raised one foot high in one minute. Indicated HP. is ascertained by calculations made from diagrams taken from the top and bottom of the cylinder of the engine and when at work. The mean or average effective pressure per square inch on the *piston during* the stroke is thus ascertained, and this multiplied by the area of the piston in square inches, multiplied by the speed of the piston in feet per minute, and divided by the 33,000, will give the I. H. P.

$(\text{Area of piston in sq. ins.} \times \text{speed in ft. per min.} \times \text{mean effective pressure}) \div 33{,}000 = \text{I.H.P.}$

D. Describe an evaporator and its fittings and state what precautions are to be observed when making water for drinking purposes.

A. Generally a round cylinder with a series of copper pipe coils in the inside, with a steam gauge; safety valve on top of evaporator; a gauge glass; blow-off valve; feed valve and steam valve not to carry over half a glass of water.

E. What will be the capacity for a steam fire pump for a 1,000 tons passenger ship and upwards?

A. Not less than 1/3 of a cubic inch cylinder capacity for every gross ton up to 3,000 and over that, not less than 1,000 cubic inch cylinder capacity. Therefore, for a steamer of 1,000 gross tons, there will be required a pump cylinder capacity of 1,000 divided by 3 or 333 1/3 cubic inches pump cylinder capacity.

C. A single screw vessel has a triple expansion engine cylinders, 30-60-100. A twin screw ship has similar engines 19-30-50 diameter. Will the twin-screw develop as much H. P. as the other and how is your conclusion *reached?*

A. No. The single screw has more H. P. than the twin screw and has more volume in her cylinders.

1. Why does a needle on a steam gauge and on a vacuum gauge go the same direction and do not register the same?

A. Because the gearing on a vacuum is different than a steam gauge, that of a vacuum gauge being set opposite.

C. Why are double-ported slide valves used and where?

A. They are used because you can get double the area of port than you can with the ordinary D slide valve, the friction is less and it decreases the pressure one the face of the valve. Used on H. P. slide valves, also L. P. in order to reduce the weight of the valve.

E. How do you cut steam off with cut-off valve?

A. With the links.

E. How does a variable cut-off do this?

A. By the expansion valve.

E. What enables an injector to lift the check and force water into a boiler with pressure on boiler and injector equal?

A. The velocity of the steam coming in *contact* with the water imparts the energy necessary to overcome the pressure. A vacuum is created by opening the overflow through the manipulation of lever.

E. How high will a pump lift water in practice? Why will it not lift it higher? How do you find the atmospheric pressure?

A. A pump will lift it only 28 ft., because that is all atmospheric pressure will support. Atmospheric pressure is found by Barometer.

A. How is heating surface of a boiler proportional to H. P.?

A. From 4 to 5 feet to a horsepower.

2. If you were burning pea coal and two or three of your grate bars broke in two and fell down could you come in under your own steam. If so, how?

A. Yes. If the center bars broke I would move the unbroken bars to center and place lengths of pipes on sides.

2. What are the advantages of superheated steam, also disadvantages?

A. Its advantage is that it is dryer, its disadvantage is, it cuts the cylinder.

2. How much coal is usually burned per square foot of grate surface per hour? Give an idea for natural and forced draught.

A. 9 to 14 for natural, 14 to 40 for forced.

F. Describe the different styles of condensers *in use in* modern practice.

A. The different styles of condensers in modern use are the Surface, Jet and Keel condensers. The first named is most generally used and consists of a circular or rectangular shell with brass or bronze tube sheets suitably designed and constructed to receive a number of seamless brass tubes with stuffing box and screw ferule arrangements to pack same to make it water tight, with a division plate on one end that the water may circulate through the tubes after the doors or covers are secured with bolts or studs with a packing joint to prevent leaking. The Jet condenser consists of a receptacle, where the steam and water mix. The Keel condenser is a modified form of surface condenser and is simply two pipes running parallel on each side of the Keel (condenser). Where the exhaust from engine goes in one end while the air pump is attached to the other end, it requires only an air pump to operate it. It requires only one pump to operate the Jet condenser, namely, an air pump. Two pumps are required to operate the surface condenser, a circulating and an air pump.

C. What is an expansion joint? Why is it used? What else is used for the same purpose? Of what material should the working parts be constructed? What precautions should be taken when using expansion joints?

A. An expansion joint is a device to prevent longitudinal compression or tension strains, in long straight pipes, due to the expansion of the *material* at high temperatures. Bends or bellows put in the pipe to accommodate the expansion of the pipe, are sometimes used instead of expansion joints. The expansion joint should be constructed of copper or some composition which will not rust or stick. The joints should have safety collars or bolts to prevent blowing-out of the pipe from the expansion joint.

D. Describe how you would set a valve.

A. Place the engine on the top center and move the eccentric around on the shaft in the proper direction (for the ahead motion, when setting the valve for the astern motion), until you have the proper amount of lead on the top center. Secure the sheave with set screw to the shaft, and then turn engine on bottom center and try by lead, and, if it is what it should be, mark key-ways, have same chipped out and keys fitted to same. Most modern jobs have a feather let into shaft in the proper position and with ample key-way in the eccentric sheave. When the proper adjustment of valve setting is made, sister keys are fitted on each side of feather; this arrangement gives ample range for experimenting.

C. Why do balance pistons often become troublesome on slide valves?

A. Inability to keep them tight, due to the uneven travel, due to working the link gear expansively and the reversing of engines while docking.

C. What is fixed cut-off and what is adjustable cut-off?

A. Fixed cut-off is an arrangement of valve mechanism, whereby the point of cut-off cannot be changed, except by shifting the eccentric on the shaft. Adjustable cut-off is an arrangement of valve mechanism, whereby the point of cut-off may be changed by hand, ofttimes without stopping the engine.

C. If your thrust block had a number of rings broken and was running hot, what would you do?

A. I would work steam pressure down on boilers by checking the fires, stop engine, remove the broken rings, renew them with spare rings and adjust the thrust setting, or make repair possible on broken rings and replace after making necessary adjustment. In the last case, I would proceed under reduced speed and run thrust bearing in water, until I arrived in port and make the necessary permanent repairs.

F. What is link motion and what are some of its advantages?

A. Link motion is a mechanical arrangement used on engines operated from the shaft of engine through eccentric and rod to link, and gives motions to valve that in turn permits steam to flow alternately, top and bottom, of steam pistons at proper time. It is used to reverse engine from one direction to the other, namely, *ahead* or astern, with rapidity and also to use the steam expansively and therefor economically.

F. What valves should be left open when getting steam up?

A. The safety valve so as to give boiler a vent and to allow air to escape the drain or petcock on steam gauge pipe. The valve on boiler to steam gauge and water column, so as to inform the engineer when the boiler was beginning to make steam and to enable him to see the water in the glass.

E. Draw an indicator card showing a long or early lead and one showing a short or late lead.

A. See page 93.

D. How would you find if the shaft were true with the cylinder?

A. By removing the cylinder cover, take out piston and piston rod, strip crank pin and put a line through cylinder to bottom of crank pit; measure line at stuffing box by calipering all round the stuffing box; get line exactly in the center and move engine until pin touches line; then make a scribe on pin; remove the line, turn engine on the center and put line exactly in the same place. If pin does not touch the line in exactly the same place, the shaft is not true with the cylinder.

C. If you failed to get sufficient cushion on your engine by the lead you had, how would *you remedy it?*

A. If it were a flat D. slide valve, I would pin strips on the edges of the exhaust cavity of valve. If it was a piston slide valve, I would increase the length of rings toward the exhaust edges, or in other words, increase the exhaust or inside lap.

C. What are the duties of an engineer as regards reporting accidents, etc.?

A. He must upon arrival of his ship in port, immediately notify the local inspector the nature of the accident, with a sworn statement of same.

2. If piston should strike the bottom of cylinder, what would you do to prevent it?

A. Put shims under the stub end of connecting rod.

2. After you clear the dock and go to change your auxiliary exhaust from overhead to condenser, what care must be exercised?

A. See that exhaust valves are open at the same time so as not to break your vacuum.

E. What is the influence of linking up on the steam distributions?

A. The travel is decreased, the lead is increased and reduces the distribution of steam.

E. What causes trouble with a feed pump at times?

A. The float in hot well out of order, loose piston, something gets under the valves or not enough water or too hot.

1. With a go-ahead eccentric broken, state how the engine could be worked safely into port.

A. Put backing eccentric in go-ahead's place and sling up the backing end of link and proceed under reduced speed. You would not back engine.

C. What parts in the engine room break down first; name at least four instances and give cause for each, also method of repairing same.

A. A broken foot, delivery or bucket valve of air pump, due to an overcharge of water, renew valves. Piston rings and spring due to water in cylinder, faulty material or adjustment.

2. Can a Salinometer be used without a Thermometer?

A. No, the Salinometer cannot be used without the thermometer as the Salinometer is graduated for either 190-200-210 degrees Fahrenheit and for that reason alone a thermometer must be used to bring the water to the proper temperature to determine its saturation with any degree of accuracy.

2. Can you get the saturation without a salinometer?

A. Yes, the boiling point of fresh water at sea level is 212 degrees F.; and of sea water is 213.2 degrees F.; and every time that the sea water increases its saturation 1/32 the boiling point is raised approximately 1.2 of a degree. From this we can readily see that we can get the saturation of boiler water approximately very close by taking a quantity of water to be tested and bringing it up to a boiling point and then taking its temperature. For instance, if the boiling point of a certain quantity of water is 218 degrees, we find that it has raised a total of 6 degrees above that of fresh water and dividing that difference by 1.2 would indicate that the saturation of that water is 5/32.

For the eighth district, which embraces all of the River St. Lawrence, Lake Erie, Ontario, Champlain and their tributaries.

The following code shall be used between the master pilot and engineer, to be made by bell or whistle.

1 whistle or 1 bell — Go ahead.
1 whistle or 1 bell — Stop.
2 whistles or 2 bells — Back.
3 whistles or 3 bells — Check.
4 whistles or 4 bells — Strong.
4 whistles or 4 bells — All right.

Two whistles or two bells shall always mean Back, irrespective of other signals given.

ATLANTIC COAST BELL SIGNALS

1 bell — Ahead slow.
1 bell — Stop.
1 bell and jingle — Full speed ahead.
1 bell — Slow.
2 bells — Stop.
2 bells — Astern, slow.
2 bells and jingle — Astern, full speed.
1 bell — Stop.

If working under one bell slow, 3 bells would mean Astern.

If working full speed ahead, 4 bells and jingle, would mean, Full speed Astern.

PROBLEMS

A pump has a two-inch diameter of cylinder, eight-inch stroke and it makes 300 strokes per minute. How much water will it pump per minute? Give answer in gallons.

$$\frac{2^2 \times .7854 \times 8 \text{ inches} \times 300 \text{ strokes}}{231 \text{ cubic inches}} = \begin{array}{l}32.64 \text{ gals.}\\ \text{per min.}\end{array}$$

A boiler with a 60 pound steam pump, 6-inch steam cylinder and a 4-inch water cylinder. Against what will she pump?

$$\frac{6 \times 6 \times .7854 \times 60}{4 \times 4 \times .7854} = \text{pressure.}$$

A pump with 6-inch diameter steam cylinder and 5-inch diameter water cylinder, using steam at 70 pounds pressure, will produce a hydrostatic pressure of 100.8. What diameter of water end will be required to produce a pressure of 157.5 pounds; steam pressure and diameter remaining the same?

$$\frac{6^2 \times .7854 \times 70}{157.5} \div .7854 = \text{diameter squared.}$$

$6 \times 6 \times .7854 \times 70 = 1979.2080. \div 157.5 = 12.5664. \div .7854 = 16$ square of diameter. $\sqrt{16} = 4''$ diameter water end.

With a fire pump 6-inch diameter, 7½-inch stroke, 30 revolutions per minute, how many gallons of water would it throw per hour?

Example—Square the diameter, multiply by .7854, multiply this by the stroke, multiply this product by the revolutions per minute, and multiply this product by the number of minutes in an hour and divide the answer by 231 cubic inches.

$$\frac{6\text{x}6\text{x}.7854\text{x}7\tfrac{1}{2}\text{x}30\text{x}60}{231}=1652.4 \text{ gallons per hour.}$$

Adonkey pump 6-inch diameter of steam piston, 4-inch diameter of water piston, and 60 lbs. steam pressure. State whether said pump would pump against a boiler pressure of 150 lbs.

Square the diameter of steam piston, multiply by .7854 and multiply this product by the steam pressure. Square the diameter of the water piston, multiply by .7854 and divide the first product by the last product.

$6\text{x}6\text{x}.7854\text{x}60=1696.46$ $\qquad$ $4\text{x}4\text{x}.7854=12.56$

$$\frac{1696.46}{12.56}=135 \text{ pounds.}$$

Not enough pressure.

A pump 2 inches in diameter, 4-inch stroke, making 300 strokes per minute. How much water will it throw?

$$\frac{2^2\times.7854\times4\times300}{\textit{231 cubic inches}}=16.32 \text{ gals. per min.} \quad \text{Ans.}$$

How many gallons of water will a pump, with diameter of cylinder 3 inches, stroke 12 inches, making 25 strokes per minute, ¾ full each stroke, extract in an hour?

$$\frac{3^2 \text{x} .7854 \text{x} 12 \text{x} 25 \text{x} 60 \text{ min.x} \tfrac{3}{4}}{231 \text{ cubic inches.}} = 413.1 \text{ gals.}$$

A centrifugal pump is used to pump out a tank 50 feet long, 19 feet wide and 3 feet deep, the tank is pumped out in 30 minutes. What weight of water is discharged per minute by the pump?

35 cubic feet of water weighs one ton.

$$\frac{50 \times 19 \times 3}{35} = 81.42 \text{ tons.}$$

$\frac{81.42}{30} = 2.714$ tons, discharged by pump each minute.

Rule to find the thrust on the guides of an engine:

Multiply the total effective pressure on the piston, when it is at half stroke, by the radius of the crank in inches, and divide that product by the length of the connecting rod, also expressed in inches. To illustrate: It is desired to know what is the maximum thrust on the guide, when the piston is at mid-stroke, when *the total* pressure on the piston at mid-stroke is

20,000 pounds, the radius of crank pin circle is 15 inches, and the length of the connecting rod is 5 feet or 60 inches. According to the rule, the statement becomes:

$$\frac{20{,}000\times15}{60\text{ in.}}=5000\text{ lbs.}$$

The formula shows that the longer the connecting rod is, the less will be the thrust on the guide, the other values remaining the same, and vice-versa. If the surface area of the crosshead shoe or slipper is known, the thrust per square inch may be found by dividing the 5,000 lbs. found above, by the area of the shoe.

What will be the safe working pressure on the shell of a boiler 11 feet long, 12 feet in diameter; thickness 1⅜ inch. Tensile strength 60,000 pounds.

Rule.—Multiply 1-6 of the lowest tensile strength found stamped on the plates in the cylindrical shell, by the thickness expressed in inches or part of an inch, and divide by the radius or half the diameter, also expressed in inches. Add 20% where the longitudinal laps of the cylindrical parts of such boiler are double riveted, when all the rivet holes of such boiler, including steam and mud drums, *have been* fairly drilled and no part of such *holes have been* punched. Note: disregard length of boiler. 1-6 of 60,000 =10,000. 12 feet=144 inches.

Radius=½ of 144 inches=72 inches.
1⅜=1.375.

$$\frac{10{,}000\times 1.375}{72}=190.9 \text{ safe working pressure.}$$

20% of 190.9=38.18 190.9+38.18=229.08 lbs. pressure allowed.

What will be the piston speed of an engine with stroke 3½ feet, making 100 revolutions per minute?

One stroke equals 3½ feet.
One revolution equals 7 feet.
100 revolutions equal 700 feet per minute.

How high will a valve have to rise from its seat to an opening equal in area to its diameter?

A. ¼ of the diameter.

An engine has 3 feet 6-inch stroke, ⅛-inch lead and 2½-inch lap. Valve travel is 10 inches. What is the point of cut-off?

Rule.—Multiply the lap by 2 and add the *lead. Divide* this sum by the travel of the valve. Square the quotient, multiply the last result by the stroke of the engine in inches, will give the distance the piston is from the end of stroke. Subtract that from the stroke gives the point of cut-off.

Example:

2½ inches=2.5×2=5 5
⅛ inch=.125 .125
3 feet 6 in.=42 in. ———
5.125÷10=.5125×.5125=.262656
262656×42=11.0315 42.—11.0315=30.97
Point of cut-off. Ans.

How much could you move your valve with a 15 inch shaft and 5-inch throw of eccentric, if you moved the eccentric one-eighth inch on the shaft?

$$\frac{.125\times2.5}{7.5}=.0416 \text{ inches. Ans.}$$

Explanation of above:

To find the greatest amount an eccentric will move a valve by advancing it on the shaft. Multiply the amount the eccentric is moved by half a throw, and divide by the radius.

The thickness of pipe and the steam pressure *allowed on all lap,* welded or solid drawn steam pipe of wrought iron or steel, shall be determined by the following formula:

P=Pressure of steam allowed.
D=Diameter of pipe.
T=Thickness of pipe.

Formula:

$$T=\frac{P\times D}{10{,}000}+.125 \quad P=\frac{(T-.125)\times 10{,}000}{D}$$

What is the thickness of steel pipe, given 200 pounds steam pressure, and 5-inch diameter of pipe?

$$T=\frac{200\times 5}{10{,}000}+.125=.225 \text{ inches.}$$

What is the pressure allowable on a steel main steam pipe 5 inches in diameter and .225 inches thick? The following formula should be used to find pressure on steel main steam pipe:

$$\frac{P=(.225-.125)\times 10{,}000}{5}$$

$$\begin{array}{r} .225 \\ .125 \\ \hline .1 \end{array} \times 10{,}000=1{,}000\div 5=200 \text{ lbs. pressure allowable.}$$

What is the required thickness of a 5-inch copper pipe for a working pressure of 175 lbs?

$$T=\frac{P\times D}{6000}+.0625\ \frac{175\times 5}{6000}+.0625=\text{required thickness.}$$

$$\frac{175\times 5}{6000}=.1458.\quad .1458+.0625=.208\ \text{Thickness.}$$

What pressure allowed on a 5-inch copper pipe, thickness, .208?

$$P=\frac{6000\times(T-.0625)}{D}\ \frac{6000\times .1458}{5\ \text{inch Dia.}}=\text{Pressure.}$$

$$6000\times .1458=874.80$$

$$\frac{874.80}{5\ \text{inch.}}=175\ \text{lbs. pressure.}$$

What pressure would be allowed on a copper pipe 12 inches in diameter and ⅜ inch thick?

$$\frac{\tfrac{3}{8}=.375-.0625\times 6000}{12\ \text{inches}}=156.25.\quad \text{Ans.}$$

What strain on a stay bolt 5¾ inches pitch and 225 pounds steam pressure?

Square of pitch multiplied by pressure:

$5.75\times 5.75\times 225=7439.0625$ lbs. strain. Ans.

A cylinder is 45 inches in diameter and 30 pounds pressure. There are 12 bolts in the cylinder head. What is the strain on each bolt?

$$\frac{\text{Diameter}^2 \times .7854 \times \text{pressure}}{\text{Number of bolts.}} = 3976.08 \text{ pounds strain on each bolt.}$$

A boiler is stayed with stays $1\frac{1}{8}$ inch in diameter, 6-inch center to center. What pressure is allowed? Work in 4 Dec.

$1\frac{1}{8} = 1.125$

$6000 = \text{constant.}$

$$\frac{1.125 \times 1.125 \times .7854 \times 6000}{6 \times 6} = 165.6 \text{ lbs. pressure allowed.}$$

The working pressure required of a stay bolt 1 inch in diameter, pitch 6 inches by 6 inches center to center.

$$\text{Working pressure} = \frac{(1 \times 1 \times .7854) \times 6{,}000}{6 \times 6} = 130.9 \text{ lbs.}$$

To find the diameter of stay bolt:

Multiply the pitch squared by the steam pressure and divide this by tensile strength, then divide this result by the decimal .7854 and take the square root of the result.

Example, find the diameter of a stay bolt with 200 lbs. pressure and pitched 6×6. Tensile strength 6,000.

$$\frac{200\times6\times6}{6000}=1.2$$

$1.2000\div.7854=1.52 \quad \sqrt{1.52}=1\frac{1}{4}$ in. bolt. Ans.

How long can you steam on 213 tons of coal, and how far can you go at 12 knots an hour? I.H.P. 3600 and coal consumption 1.68.

$$\frac{1.68\times3600}{2240}=2.7 \text{ tons per hour.}$$

$$\frac{213}{2.7}=\text{hours run}\times12\text{ knots}=947\text{ knots.}$$

How much coal required on a seven days' voyage, I.H.P. 2400, coal consumption 1.78, allow ten per cent.?

$$\frac{1.78\times(24\times7)\times2400}{2200}=326.22+10\%. \text{ Ans.}$$

If you were going to make a voyage of two days and had four boilers, each having three furnaces 5 ft. by 3 ft., natural draft, how much coal would you order for the voyage, allowing 42 cu. ft. to a ton? Allow 16 lbs. of coal per hour for each sq. ft. of heating surface. Time 2 days, 4 boilers, 3 furnaces in each *boiler, or 12 in all.*

Example:

$\frac{5\times3\times12\times16\times48}{2240}=61.7$ tons, amount of coal ship would consume. Ans.

If you had a boiler set thwartship 10 feet long, and had 10 inches of water over your crown sheet, when on even keel. If your ship took a list of 15 degrees to port, how much water would there be over your sheet, if any, on the starboard side?

$\frac{10\text{ ft.}=120\text{ in.}\ \times3.1416}{360\text{ degree}}\times15\text{ deg.}-10\text{ in.}=5.7$ in. below.

With six boilers, 3 furnaces, each 6x3½, burning 16 lbs. per hour on each square foot of grate surface, making 15 knots per hour, how many tons of coal required to make a voyage of 3,000 knots, taking 2,000 lbs. per ton? How many tons used per day?

A:—

$\frac{6\times3.5\times18\times16\times24}{2000}=72.57$ tons per day.

B:—

$\frac{3000}{24\times15}=8\frac{1}{3}$ days required to make voyage.

$72.57\times8\frac{1}{3}=604.50$ tons required for the voyage. Ans.

How many gallons of oil will a tank hold, 3 feet 9 inches long, 31 inches wide and 39 inches high? Give answer in gallons.
$31 \text{ in.} \times 39 \text{ in.} \times 45 \text{ in.} \div 231 \text{ in.} = 235.5$ gallons. Ans.

With boiler stays 5½ inches from center, ⅞ round iron, what steam pressure would be allowed, if 1 sq. inch of the same iron would stand a strain of 6000 lbs., or allowing 6000 lbs. per square inch of section of stays?

Example: Square the distance from centers, reduce the thickness of the iron to a decimal, square this decimal, multiply this by .7854 and multiply this product by the pounds pressure per square inch and divide this product by the square of the stays from centers.

$5.5 \times 5.5 = 30.25 \quad \tfrac{7}{8} = .875 \times .875 = .7656$

$.7656 \times .7854 = 6013$

$6013 \times 6000 = \dfrac{36078000}{30.25} = 119.26$ lbs. pressure.

Find the maximum stress allowable on a flat surface, 7/16 inch thick, stayed 6x6?

Formula: Working pressure $= \dfrac{C \times T^2}{P^2}$

C=112 for plates 7/16 inch or under.
T=Thickness of plate in sixteenths of an inch.
P=Pitch.

$\dfrac{112 \times 7 \times 7}{6 \times 6} = 152+$ lbs. working pressure.

To determine the area of a safety valve for boiler using oil as fuel or for boilers designed for any evaporation per hour.

Example: Find the area of a safety valve for a boiler using oil as fuel, which evaporates 8,000 lbs. of water per hour at 175 lbs. gauge pressure, and 200 lbs. of water evaporated per square foot of grate surface per hour.

$$\frac{8000}{200}=40 \text{ square feet grate surface.}$$

$$\frac{40}{175}=.228 \text{ square inches.}$$

$$.228\times 40=9.12 \text{ square inches total area.}$$

AREA OF SAFETY VALVE

Given boiler pressure equals 75 pounds per square inch. Grate surface equals 33 square feet.

Water evaporated per pound of coal equals 8 pounds. Coal burned per square foot per hour equals 12½ pounds. Area in square inches required per square foot grate surface equals .230. Find area.

Area equals square feet grate surface × area in square inches required per square foot grate surface.

$12\frac{1}{2}\times 8=100$ lbs. evap. per square ft. per hour.
$33\times .230=7.59$ sq. inches area of safety valve.
Diameter=3½ inches.

A boiler is stayed 7½ x 8 and carries 175 pounds steam pressure. One stay breaks. What is the extra load carried on surrounding stays, and how is it divided?

$$7.5\times8\times175\text{ lbs.}=10500$$

$$\frac{4\text{ stays}}{10500}=2625\text{ extra load.}$$

Find push and pull on a crank pin, with 72 inches cylinder, 10 lbs. steam pressure, 26-inch vacuum?

$$(\text{Sq. of Dia.}\times.7854)\times(26\div2+10\text{ lbs.})=\text{Push and Pull.}$$

$$72\text{ in.}\times72\text{ in.}=5184\times.7854=4071.5136$$

$$26\div2=13+10=23 \qquad \begin{array}{r}4071.5136\\ 23\\ \hline 93644.8128\end{array}$$

=push and pull. Ans.

What will be the pressure on head engine going down, given 60 inches diameter of cylinder, 8 lbs. steam pressure and 26-inch vacuum? What is the push and pull?

$$60\times60\times.7854=2827.44\times8\text{ lbs.}=22619.52\text{ lbs. pressure.}$$

$$60\times60\times.7854\times(26\div2+8)=59{,}376.24\text{ Push and Pull.}$$

What is the projected area of crank pin, diameter 11 inches, length of pin 14 inches?

Dia.×Length.

Tensile strength of plate. Multiply the thickness of plate by the width of plate and divide the result into the parting strain.

Width, ½-inch	.5
Thickness, ½-inch	.5
Parting strain, 15,000 lbs..	.25)15000
	60000 lbs.

PRESSURE ON SHELL OF BOILER

What is the strain on rivets of a boiler 60 inches diameter, 80 lbs. steam?

Multiply one-half of the diameter of boiler by steam.

$$60 \div 2 \times 80 = 2400 \text{ lbs. Ans.}$$

LONGITUDINAL STRAIN ON A BOILER

Multiply the diameter squared in inches by .7854, and then by the steam pressure and divide this result by 3.1416×diameter in inches.

$$\frac{D^2 \times .7854 \times P}{3.1416 \times D} = \text{strain.}$$

DUCTILITY OF PLATE.

Subtract area after breaking from area before breaking and divide by area before breaking.

.5 .36
.5 .34
.25 area before breaking. 144
108
.1224 area after breaking.
.2500
.1224
25).1276(51 per cent.+Ans.
125
26

The pressure for any dimension of boiler should be ascertained by the following rule: Multiply one-sixth of the lowest tensile strength found stamped on the plates in the cylindrical shell by the thickness — expressed in inches or part of an inch — and divide by the radius or half diameter, also expressed in inches, and the result will be the pressure allowable per square inch of surface or single riveting, to which add 20 per cent. where the longitudinal laps of the cylindrical parts of such boiler are dobule on the plate whose tensile strength multiplied by its thickness gives the *lowest product.*

A coal bunker is 15 feet across of a perfect cube. How many tons of coal will it hold at 42 cubic feet to a ton?

$15 \times 15 \times 15 = 3375$ cubic feet
$3375 \div 42 = 80.3$ tons. Answer.

A coal bunker is 18 feet 9 inches long, 12 feet 6 inches wide and 6 feet 9 inches high. How many tons of coal will it hold?

Allow 45 cubic feet to one ton.

$$\frac{18.75 \times 12.5 \times 6.75}{45} = 35.1 \text{ tons.}$$

A thwartship bunker is 20 feet long, 10 feet high, and its width is 15 feet at middle and 10 feet at bottom, 20 feet at top. How many tons of coal will it hold at 45 cubic feet to a ton?

Rule:—Add the first and third and four times the middle and divide by six, gives width.

$$\frac{W \times H \times L}{45} = \text{ans.}$$

$$\frac{20 + (4 \times 15) + 10}{6} = 15 \text{ feet width.}$$

$$\frac{15 \times 20 \times 10}{45} = 66\tfrac{2}{3} \text{ tons. Ans.}$$

A cylindrical oil tank is 4 feet 6 inches long by 1 foot 9 inches in diameter. How many gallons will it hold?

One gallon contains 231 cubic inches.

4 ft. 6 in.=54 in. in length. 1 ft. 9 in.=21 in. in diam.

$$\frac{D^2 \times .7854 \times 54}{231} = 80.9 \text{ gals. Ans.}$$

A propeller is 9 feet in diameter, 20 inches across the blades, and the forward corner is 9½ inches in advance of the after one. 20-inch piece thread. What is the pitch? The square root of piece thread squared minus piece pitch squared=piece of circumference, or 17.6.

$$\frac{\text{Dia. in inches} \times 3.1416 = \text{cir.} \times 9.5}{17.6} = \text{pitch.}$$

$$\sqrt{9.5^2 - 20^2} = 17.6$$

9 ft.=108 in.×3.1416×9.5=3223.255 inches.

$$\frac{3223.255}{17.6} = 183.19 \text{ inches} = 15.26 \text{ feet pitch.}$$

A propeller at 80 rev. per minute and 25% slip, drives the ship at a speed of 15 knots an hour. What would the speed be, with this propeller making 100 revolutions and having a slip of 30%?

30% of 100—100=70 revs. doing actual work.

25% of 80— 80=60 revs. doing actual work.

$$\frac{70 \times 15}{60} = 17.5 \text{ knots speed. Ans.}$$

A propeller 18 ft. pitch, making 120 rev. per minute, apparently would advance the ship 18×120 or 2160 feet. If the real advance is only 1600 feet, what would be the percentage of apparent slip? If your wake were 15%, what would be the percentage of true slip?

Example:

$1600-2160\div2160=.25$ or 25% apparent slip.

$$\frac{(1600\times15\%-1600)-2160}{2160}=.37$$ or 37% true slip. Ans.

To find percentage of slip of wheel, ship speed 170 knots by wheel, 150 knots by observation.

$W-O\div W=$percentage Slip.

170 by wheel.

150 by obs.

170)20(.117 percentage slip.

What distance will a ship travel in 24 hours with engine making 60 rev. per minute, pitch of wheel 15 ft., 24 hours run?

60 min. × 60 rev. × 24 hr. × 15′ P.

$60\times60=3{,}600$ per hr. $3{,}600\times24=86{,}400$ per day. $86{,}400\times15=1{,}296{,}000$.

$1{,}296{,}000\div6{,}080=212.9$ travel in 24 hrs.

The tensile strength of steel used in the construction of corrugated or ribbed furnaces shall not exceed 67,000 and be not less than 54,000 pounds; and in all other furnaces the minimum tensile strength shall be not less than 58,000 and the maximum not more than 67,000 pounds. The minimum elongation in 8 inches shall be 20 per cent.

All corrugated furnaces having plain parts at the ends not exceeding 9 inches in length (except flues especially provided for), when new, and made to practically true circles, shall be allowed a steam pressure in accordance with the following formula:

Morrison Corrugated Type.

$$P=\frac{C\times T}{D}$$

P=Pressure in pounds.

T=Thickness in inches, not less than five-sixteenths of an inch.

D=Mean diameter in inches.

C=15,600, a constant.

To find the bursting pressure and the working pressure of a boiler 15 ft. 9 in. in diam. Circumferential double riveted seams, thickness of plate 1 23/32, tensile strength 62.700, longitudinal seams quadruple riveted, with butt straps .923% strength.

Thickness of plate 1.71875.
1/6 tensile strength .10450.
½ Diam. of boiler in inches 945.

$$\frac{1.71875 \times 62.700}{945} = 1139 \times .923 = 1051.297 \text{ lbs.,}$$

Bursting Pressure.

$$\frac{1.71875 \times 10450}{945} = 190 \text{ lbs. Working pressure.}$$

Single riveted.

Add 20% for double riveted seams.

SAFETY VALVE

The chief purpose of the Safety Valve is its use for the escape of the steam, in case the pressure should rise above the safe working limit, for which the valve is set.

The valve is kept down on its seat by a weight on a lever. In its up and down motion, it is guided by the double stem, so that it cannot become jammed in the chamber. The pressure of the steam comes on the bottom of the valve, and as it reaches or passes the limit for which the adjustment is made, the valve lifts and the steam escapes about the edge. The actual lift of a Safety Valve is very small, one-eighth inch usually being a large lift.

Rule for finding the weight necessary to put on a Safety Valve lever, when the area of

valve, pressure, weight of valve and stem, length of lever, etc., are known.
Dia. $(4\text{ in.})^2\times.7854=$Area.

Distance center valve to ful. =3 in.
Steam Pressure =65 lbs.
Weight of lever =12 lbs.
Weight of V & S =6 lbs.
Length of lever =34 in.

Multiply the area of the valve by the pressure in pounds per square inch, this product multiplied by the distance from the center of valve to the fulcrum. From this final sum, subtract weight of lever multiplied by one-half length of lever, plus weight of valve and stem multiplied by distance from center of valve to fulcrum and divide the remainder by the length of lever; the sum thus found will be the required weight.

Formula:

$$\frac{(A\times P\times\text{distance of V to F})-\text{W of L}\times\tfrac{1}{2}\text{L of L})+(\text{W of V \& S}\times\text{Dist. V to fulcr.})}{\text{LENGTH OF LEVER}}$$

Problem:

Problem; 4 in.×4 in.×.7854=12.5664 in. Area.
12.5664×65 lbs.×3 in.=2450.4480
12 lbs.×17=204 222.
6 lbs.× 3= 18 2228.4480
222
2228.4480÷34 in.=65.5 Weight necessary.

Problem:

Diam. 4½ in.
Dist. from F to center of V 4½ in.
Steam Pressure 95 lbs.
Weight of Lev. 18½ lbs.
Weight of V & S 8¼ lbs.
Length of Lever 40 in.

18.5×20=370.
8.25 lbs.×4.5= 37.125

407.125
4½×4½×.7854=15.904×95×4½=6798.96
6798.96—407.125÷40=159.7 lbs. Wt. Req.

W=Weight of ball near end of lever in pounds.

G=Weight of lever in pounds.

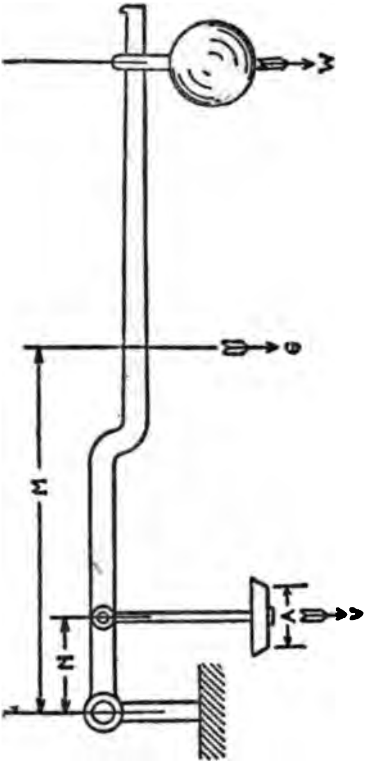
V=Weight of valve and stem in pounds.

P=Boiler pressure in pounds per square inch.

N=Distance from fulcrum to center of valve in inches.

M=Distance from fulcrum to center of gravity, or, one-half length of lever.

A=Area of valve in square inches.


W
G
V
A
N
M

DIRECTIONS FOR TAKING DIAGRAMS

These directions for taking diagrams apply to all makes of indicator: Before attaching the indicator to the engine, see that it is in good working order, and clean. The piston should move freely. See that the joints of the various levers and links are oiled with fine oil and that they are slack enough to avoid friction, yet not so slack as to allow the pencil to shake. Adjust the pencil so that it just touches the paper, and sharpen the point so that it makes a very fine, light line. A heavy, coarse line on a diagram indicates poor work.

Select a spring that will give a diagram about 1½ or 1¾ inches in height. A stiffer spring is required on a fast-running engine than on a slow-running engine, when the steam pressure is the same. See that there is no back-lash between the piston and the spring.

Adjust the length of the cord, so that the drum turns backwards and forwards without striking either of the stops at the end of the travel. If it touches both, the travel of the drum is too great, and the cord must be fastened to a point on the reducing motion having less travel. When it touches one or the other, of the stops, the cord is either too short or too long.

Keep the drum moving only when taking diagrams. Unhook the cord before putting a paper on the drum. In putting on the card *see that it fits* the drum without wrinkles, and fold back the projecting edges over the clips, so that they will not touch the pencil lever.

Turn on the steam a minute or so to warm the indicator, before taking the diagram; then press the pencil lightly on the paper, long enough to take a single diagram. Shut the cock and again press the pencil to the paper. Since the indicator piston is then subjected to atmospheric pressure only, the pencil will make a straight line called the atmospheric line. Disconnect the cord and remove the card. Write on the card the scale of the spring used, the speed of the engine, and any other desired particulars.

If one indicator is used for both ends, first open the three-way cock to admit steam from one end. Take the diagram and open the cock to the other end, and take the diagram from that end. Then shut off the steam entirely and take the atmospheric line.

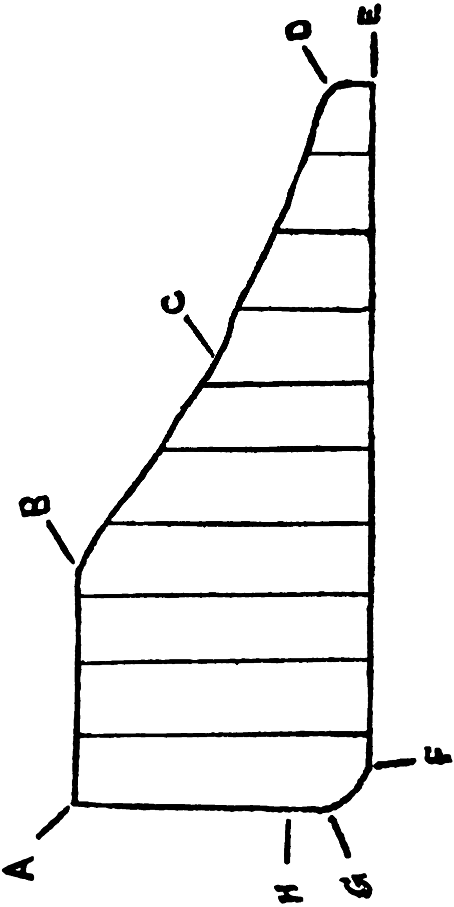
INDICATOR CARD EXPLANATION

A=Beginning of stroke.
B=Cut-off.
C=Expansion Curve.
D=Exhaust opens.
E=End of Stroke.
F=Exhaust closes.
G=Compression.
H=Lead.

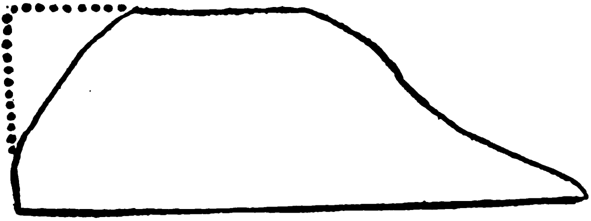
Sketch an indicator card and explain how to find the Horsepower.

A. To find the mean pressure, divide the card into ten equal parts, measure distance on each line, add them together and divide by 10. Multiply by number on spring with which card was taken, for mean pressure.

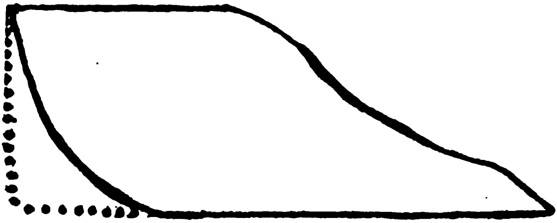
M. E. P. × area of piston × twice the stroke in feet × revolutions per min. and divide by 3300=H. P.



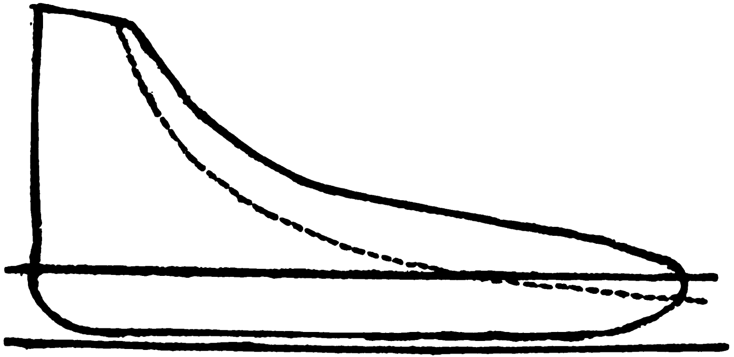
E
D
C
B
F
A
H
G



Card shows a late lead.

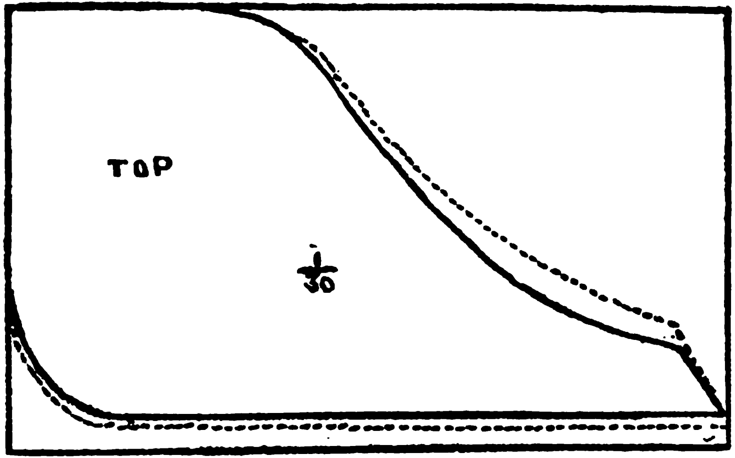


Card shows an early lead.



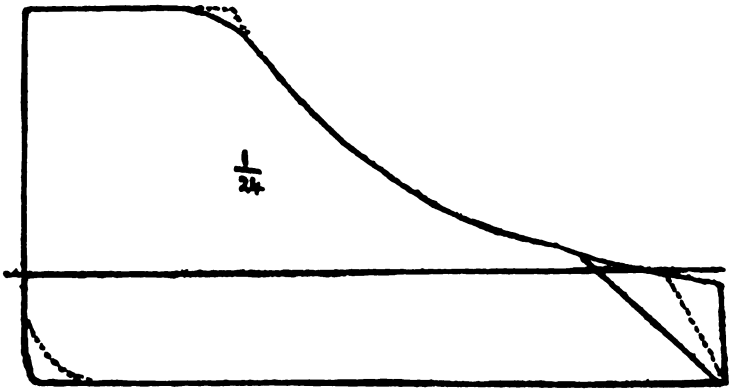
LEAKY VALVE

Here the expansion line rises much above the theoretical curve, which shows that the valve leaks and allows steam to enter after cut-off.



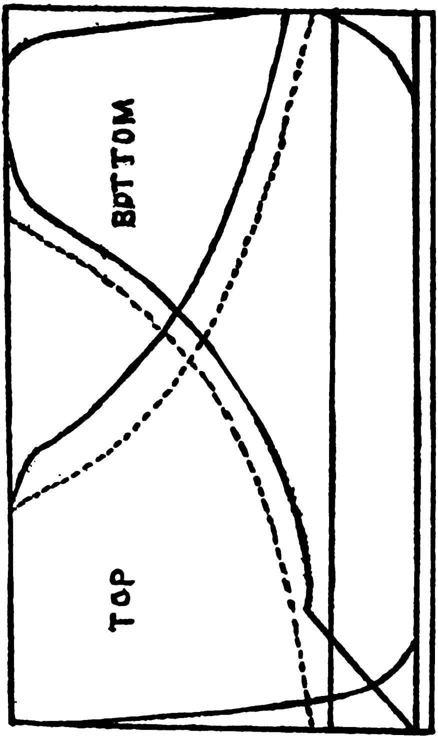
LEAKY PISTON

The steam passing through leak on to the other side of piston, causes the expansion cure to fall. The strong steam from the other side finds its way back again, when the exhaust stroke is taking place, and tends to raise the back pressure on the piston.



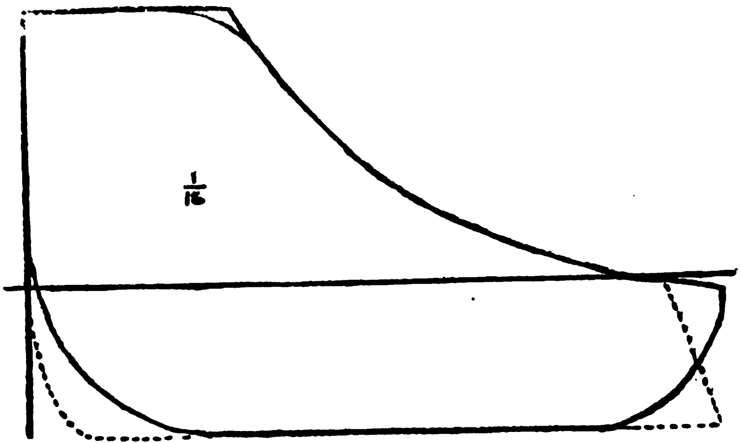
OPENS TOO SOON—CLOSES TOO LATE

This card shows that she opens to the exhaust too soon, and closes to late. The lead is good. You should pin a piece on to the exhaust edge of the upper face of the valve.



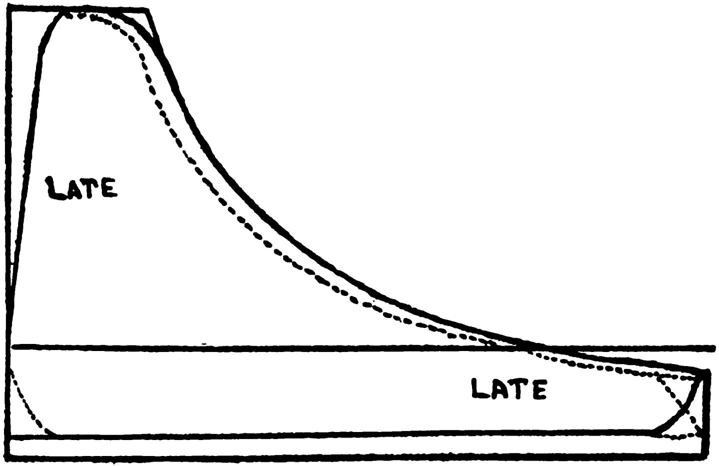
DOUBLE CARD

This card shows that there is too much lead at the top; and no lead at bottom. It needs lining up.



OPENS TOO LATE—CLOSES TOO SOON

This card shows that she opens too late, and closes too soon, the lead is good. In this case take a piece off of the exhaust edge of the upper face of the valve.



EVERYTHING TOO LATE

This card shows no lead, opens too late and closes too late. Advance the sheave forward a little.

GAS ENGINE QUESTIONS AND ANSWERS

Q. Into what two classes, as regards "cycles," are gas engines generally classed, and tell what each mean?

A. Two and four cycle. Two cycle means that the cycle or function is completed in two strokes of the piston. Four cycle means that the cycle or function is completed in four strokes of the piston.

Q. Are they generally single or double acting, and why?

A. Most generally single acting. The reason is that you would experience great trouble in packing the piston rod to produce the necessary tight joint for double acting gas engines.

Q. What kind of valves do each kind have? Mention those of each.

A. The valves of a two cycle engine are stationary ports, which are opened and closed by the action of the piston. The valves of a four cycle engine are usually poppet or mushroom valves. The advantage is the simple mechanism to operate them. Some four cycle engines have sliding sleeve valves and others have rotary valves. The two latter types are not in general use.

Q. Explain in detail the action of a four cycle gas engine.

A. The piston would be drawn out of the cylinder by the turning of the crank shaft, creating a suction or partial backing, a valve would be mechanically opened and a charge of gas would be drawn into the cylinder, as the piston reaches the end of its stroke the valve will close and the piston returning back into the cylinder will compress the charge of gas in the combustion chamber. At the end of the compression stroke an electric spark ignites the compressed gas causing an explosion, which would drive the piston out of the cylinder and produce the power stroke, at the end of the power stroke another valve would be opened mechanically and the piston returning back into the cylinder would force out the burnt gases completing the cycle.

Q. What general classes of ignition are there?

A. Make and Break or Jump Spark.

Q. How do you get a gasoline engine ready and how do you start it?

A. I would see that the engine was disconnected from the parts it is supposed to drive, then I would see that my water was turned on, see that I had enough oil, see that I had enough gasoline and that it was turned on, see that the throttle of the carburetor is open ¼, see that the spark was retarded and that the ignition switch was on. Then to start I would turn the engine over, or crank it.

Q. What is meant by timing an ignition, what kind can be set the best, that is the most certain?

A. Timing the ignition means, timing the spark so that it happens when it is necessary, Jump spark can be set the best and is the most certain.

Q. If you use a battery for ignition, what else is generally used?

A. A magneto or generator.

Q. What are some of the causes of failure to start?

A. No spark, no compresion or no gas.

Q. What would be the mater if engine started off and then weakened?

A. Gasoline supply partly shut off, weak batteries, lack of lubrication, lack of compression or overheating of the engine.

Q. What causes premature ignition?

A. Spark advanced too far, excessive carbon deposits or engine overheated.

Q. What causes explosion in crank case?

A. Crank case explosion, if a two cycle engine, not enough gas, excessive carbon deposits, engine overheated, spark timed wrong, *or muffler* clogged up.

Q. What causes explosion in the muffler?

A. Unburned gas entering the muffler and being exploded by the gases from the other cylinders that are firing.

Q. How much compression, generally speaking, is good practice to have in cylinder?

A. From 60 to 75 pounds per square inch.

Q. What is carburetor?

A. A device to vaporize a liquid fuel and mix it with the correct portion of air.

Q. What are the principal parts of a carburetor?

A. Float chamber, float, float valve, spray nozzle, needle valve, mixing chamber, primary air inlet, auxiliary air inlet and throttle valve.

Q. What is a vaporizer?

A. A vaporizer performs the same duty as a carburetor, but not as well, and it is obsolete.

Q. How is gasoline fed and with what is it mixed?

A. It is fed to the carburetor by gravity, by vacuum, or pressure. It is mixed with air.

Q. About what are the proportions of mixture?

A. From 12 to 16 parts air to one part gasoline.

Q. What is back firing?

A. Not enough gasoline, inlet valve not closing properly, spark timed wrong, or cylinders wired wrong.

Q. What precautions would you take in piping up a gasoline boat and what with regards to tank?

A. See that I had some kind of flexible metal piping, that would stand vibration, see that the connections were tight and that I had a shut-off valve at my supply tank, see that my tanks were situated so that they would have sufficient ventilation.

Q. What is the greatest danger from its escape?

A. Explosion.

Q. If the cylinder got overheated, or the piston dry, what may be the result?

A. The result would be that the piston or cylinder or both, would become scorched or scratched or the piston may freeze.

Q. What causes pounding in gasoline engine?

A. Spark advanced to far, excessive carbon deposits, overheating, lack of lubrication, or mechanical looseness.

Q. Are gasoline engines usually reversible?

A. No, unless it be a two cycle.

Motor vessels of any tonnage other than steam vessels must be provided with a whistle *to be blown* by compressed air, or other power, to give necessary whistle signals to passing vessels.

To find the horse power of a Gas Engine.

(Area of piston in square inches×M.E.P.× length of stroke in feet × number of explosions per min.)÷33.000.

Q. What is a spark coil?

A. Spark coil is a coil used to intensify the electric current. It consists of an iron core wound with wire; first with a heavy or primary wire, and then a great many turns of a thin, secondary wire.

Q. Of what does an electric batery consist?

A. An electric batery consists of sulphuric acid acting on zinc and carbon.

Q. Name some of the causes of electric igniters failing to work.

A. Some causes are: weak cable, short circuit, a break in the circuit, or sooty points on the spark plug.

Q. What do you consider the best material for making joints on a gasoline engine?

A. I consider paper joints the best.

Q. Why are gasoline engines fitted with a water jacket?

A. To keep the cylinder cool.

Q. Should any provision be made for draining the water jacket?

A. Yes. In freezing weather, so that the water jacket will not crack or burst.

Q. Where do you get the supply of circulating water and how is it arranged?

A. You can get your supply of water from overboard with a rotary pump, or plunger pump, by pumping it from the bottom, up through cylinder overboard.

A. At what temperature will the circulating water give the best results?

A. At about 80 degrees.

Q. Do you consider explosions in the muffler dangerous; if so, what pressure should they be constructed to withstand?

A. About three times as much as the cylinder can stand.

Q. How would you proceed to stop a gasoline engine?

A. Break electric circuit by opening switch, or shut off gasoline.

Q. Is the gasoline tank perfectly air tight, or is it necessary for it to be provided with an air vent?

A. A gasoline tank should never be perfectly air tight; if it were, it would be apt to cause an explosion, from the expansion of the gasoline.

Q. If your engine were pounding, caused by the journals, crank boxes, or piston heads being loose, what would you do?

A. Stop engine and take up all loose motion.

Q. Why is it necessary to have the battery connections thoroughly insulated?

A. So you will not lose the current and so as not to make a short circuit.

Q. How would you operate an engine using an electric spark?

A. Put engine in position, give it fuel and then give her a spark.

Q. How does the ignitor on a hot tube engine ignite its charge?

A. By heating the bulb to a certain temperature, giving her a charge of fuel in the top of the bulb and from the heat of the bulb, the fuel is exploded.

Q. What is a muffler and where is it attached to the engine?

A. A muffler is a space where the exhaust gas goes into, and from there out into the air. It is attached to the exhaust valves of the engine.

Q. What two forms of ignitors are used on marine gasoline engines and which do you consider the best?

A. Electric spark igniters and hot tube igniters. I prefer the hot tube, because it is the steadier of the two, when you keep it hot. If *you prefer the* electric, state why?

Q. Explain how you would operate an engine using a hot tube.

A. I would heat the tube red hot, put the piston in position, give it a charge of fuel and continue to keep tube warm.

Q. From what do you receive the electric current, and how is it connected to the engine?

A. You receive the electric current from the batteries, or magneto; it passes through the spark coil and is connected to the spark plug.

Q. At what part of the stroke should the charge ignite to give the best results?

A. A little way over top center.

Q. Is it necessary to use any care in examining the interior of crank case, engine cylinder, or gasoline tank?

A. Yes. If the engine should be running without oil, it is apt to run the metal out of the crank and bearings and it will cut grooves in the cylinders and piston. It is also necessary to examine the gasoline tank to see that there is no dirt in it, which may stop up the carburetor.

Q. When is it necessary to use a pump for supplying engine with gasoline?

A. When the gasoline tank lies lower than the carburetor.

TURBINE QUESTIONS AND ANSWERS

Q. What two fundamental types of Turbine engines are there?

A. The "Reaction" and the "Impulse" type.

Q. Describe briefly the fundamental action of the Impulse type.

A. In the Impulse type of Turbine, the expansion of steam takes place in the stationary nozzles and the steam is then directed against the moving blades. The energy of motion, as it is called, gained by this expansion, is used to drive the revolving disks and attached blades around.

Q. Describe briefly the fundamental action of the "Reaction" type.

A. In the "Reaction" type of Turbine, the expansion of steam takes place in the moving blades themselves. The energy gained by this expansion acts with "reactive" force against the blades and drives them and the attached rotor around. In this type very little expansion takes place in the stationary blades.

Q. What is the purpose of the Reduction Gear and why is it necessary?

A. The reduction gear, as its name implies, is to reduce the high speed of the Turbine to the comparatively low speed of the propeller. It is necessary because the Turbine is fundamentally a high speed machine and any attempt to slow it down considerably will result in a loss of economy. The best results, on the other hand, are obtained from the propeller when it is run at comparatively low speed. In order to combine the best results of the two, some medium must be used. Hence the Reduction Gear.

Q. What is the object of the Floating Frame?

A. The object of the Floating Frame is to correct errors of alignment and to allow of more perfect tooth contact when the High Speed Pinion is in mesh with the gear; thus eliminating the danger due to concentration of stresses and strains on a smaller portion of the teeth when in mesh, due to faulty contact.

Q. What are some of the advantages of the "Electric Drive?"

A. Ease in maneuvering, full power available for backing and it does away with large reduction gear element.

Q. Why is it advisable to use superheated steam in a Turbine of the Impulse type?

A. It is advisable because, in using ordinary dry steam, not superheated, when the expansion takes place the quality becomes *lower. That* is, particles of water are present in the steam. As the steam is shot against the blades with terrific force the " Sand Blast effect " of these particles of water may in time loosen the blades and cause blade breakage. The difficulty is avoided to a great extent by using superheated steam.

Q. In a reaction type of Turbine, what in particular must be watched very carefully?

A. The " Blade " tip clearances. In some cases they are as small as .025 of an inch. In the impulse type, the " Blade " tip clearances are much larger in general than in the " Reaction " type.

Q. Why is it necessary for the "Astern" element to revolve in a vacuum when the turbine is under ahead motion?

A. In order to prevent Windage which would cause heating of blades if the Astern element were revolved in a pressure when the turbine was under ahead motion, also when revolving in a vacuum there is no " Braking " effect or back pressure acting against the turbine ahead element.

Q. In making ready to get under way what important auxiliary system is started first, considering the engine room with a turbine installation?

A. The forced lubrication system.

Q. Why is the diaphragm used between the *ahead* reaction blades and the astern blading on *the high* pressure turbine?

A. When running ahead the astern turbine, through which no steam is passing, is revolving in a chamber in which the pressure is the same as that in the condenser because it communicates direct with the condenser through the astern element of the L. P. turbine. When running astern this condition is reversed. It is therefore necessary to separate these chambers so that the two different pressures may be maintained without a large steam flow from the higher pressure to the lower pressure, with the resultant loss in efficiency. It is necessary that the idle element, when running either ahead or astern, shall revolve in as nearly a perfect vacuum as possible as there would be a great deal of friction were there any pressure. The diaphragm is therefore used to separate these two chambers and to reduce the steam flow, or leakage, to a minimum.

Q. Why is it not used on the L. P. turbine nor on the single cylinder complete expansion unit?

A. Because both ahead and astern elements exhaust into the same chamber and therefore revolve in the same vacuum at all times, independent of whether the ahead or the astern element is being used.

Q. What is the construction and the operation of the spindle glands?

A. The gland consists of two parts, the steam seal and the water seal. The steam seal consists of a series of aluminum strips, steam being admitted to the centre and enough pressure is carried to allow a small amount of steam to blow out to the engine-room. This insures that no air is passing into the turbine and is used while " standing by " or when running up to " half speed ; " the water seal acts like the runner of a centrifugal pump connected to a supply tank above but with the supply empty. When above " half speed " the water from the supply tank tries to pass inward past the runner but is prevented from doing this by the centrifugal force of the runner, which catches the water causing it to revolve. Thus the water cannot pass inward nor can the air enter the turbine.

Q. Why is the balance piston or dummy used?

A. In order to obtain equal pressures on the ends of the spindle and the reaction blades in a reaction turbine. This practically does away with the heavy end thrust which exists due to one end of the spindle being under high steam pressure and the other end under low steam pressure.

Q. What is meant by " blade clearance? "

A. Radial tip clearance, or in other words, the clearance between the tips of the rotating reaction blades and the cylinder wall. The clearance between the stationary blades and the spindle body is always a little greater than the above and when taking clearances the sta*tionary* blades should not touch the spindle *body*.

Q. Do all reaction blades have the same clearance?

A. The amount of clearance depends upon the length of the blades, the longer the blades the greater the clearance. Different turbine builders design their turbines to run at different speeds, different blade lengths and different clearances but it is quite safe to say that no turbine should have less than .030 clearance in each direction from the centre.

Q. Why is a high vacuum so essential in turbine operation?

A. Too much stress cannot be laid upon the necessity of carrying a high vacuum. The higher the vacuum the more energy there is available in the steam for producing work. The power absorbed by the astern element when running ahead is reduced by having a high vacuum and this condition is reversed when running astern. When there is low vacuum when running astern the power absorbed by the ahead element is so great that it not only reduces the astern power but may even cause trouble due to overheating if the turbine is allowed to run too long astern when the vacuum is low. With the turbine exhaust temperature at 100 degrees F., or better, there is no danger of this. It must be remembered that owing to the construction of turbines there cannot be the power available for astern operation and all that can be done to obtain the best results must be done by the operating engineer. As a final word, ***keep after air leaks and keep the condenser*** clean.

Q. What is the danger, if any, in "warming up" a turbine?

A. The steam must not be allowed to "blow through" as in "warming up" a reciprocating engine. The steam will not follow the spindle evenly and will either warm the top or the bottom which will cause distortion. This will not be apparent until the vessel is under way when a blade rub will be noticed, as the clearances are so fine (see answer to "blade clearance" question), that the slightest distortion, or buckle in the spindle will cause a rub. Consequently do not allow the turbine to "blow through," but get the spindle in motion as soon as possible after steam is admitted. A few revolutions is all that is necessary, either ahead or astern, and this can be easily accomplished whether at anchor or at the dock.

Questions and Answers

On Condensate Pumps, Air Ejectors and Condensers.

In most instances the air pump has been displaced by the air ejector and the condensate pump working in unison. This is particularly true in turbine operation and these few questions and answers are written with the idea of instructing the marine engineer in their fundamental principles.

Q. What is the function of the condensate pump?

A. To remove the condensed steam.

Q. Why is the condensate pump operated at constant speed?

A. Variable speed is unnecessary because the characteristic of the condensate pump is such that the head of the pump can discharge against it nearly constant with the varying amount of condensate discharged.

Q. Why is submergency over the condensate pump necessary and what is the minimum amount?

A. The water handled by the pump approaches the boiling point of the vacuum at the pump suction. If the pump was above the water level the water would evaporate before being lifted by the pump. The minimum amount of submergence allowed is 30″.

Q. Why is the suction vented?

A. As the water is near the boiling point there is a tendency for vapor to be given off. It is necessary that this vapor be constantly removed in order to insure the runner being full of water and not part water and part vapor, thus causing the pump to become "vapor bound."

Q. How is this vent connected?

A. The connection is made between the air ejector suction line and the highest point on the condensate pump suction chamber.

Q. Is there danger of the condensate pump *runner* running dry?

A. Yes, when the turbines are stopped or when working to signals from the bridge.

Q. Why is this?

A. Because there is not enough water in the condenser to supply the pump and the clearances are so close between runner and pump liner that the runner must have sufficient supply of water to prevent " seizing."

Q. Is there no provision made to prevent this?

A. There is a small line run from the feed and filter tank to the condensate pump suction which must be opened whenever the turbines are " slowed " or " stopped." This small line will supply sufficient water to prevent the pump from running dry. **This is important.**

Q. What difference is there between the reciprocating air pump and the LeBlanc air ejector?

A. The air pump removes the air by displacement. The ejector removes the air by friction of the air with the jets.

Q. Why is the air ejector superior to the reciprocating pump for **high vacuum** installation?

A. As air at high vacuum has a very large volume a very large reciprocating pump is necessary. With the ejector the air is given a very high velocity and therefore a very much *smaller apparatus* can be used.

Q. What is the function of the air ejector?

A. To remove all vapor that cannot be condensed at the temperature and pressure maintained in the condenser.

Q. What attention should air ejectors have?

A. The nozzles should be kept in a perfectly clean condition and the steam strainers should be examined frequently.

Q. Why is the thermal efficiency of the ejector high?

A. The heat of the steam used in the ejector is practically all regained in heating the feed water.

Q. How is the heat regained from the ejector discharge at full load?

A. By heating the condensate in the air separator.

Q. What provision is made to prevent loss of steam at light loads?

A. When there is not sufficient condensate to condense the ejector steam, the steam is condensed in the small surface condenser which forms a part of the air separator.

Q. What is the function of the air separator?

A. The air separator condenses the ejector steam and separates the entrained air which is allowed to escape to the atmosphere.

Q. Of what does it consist?

A. A jet condenser and a surface condenser.

Q. Where does each section obtain its water supply?

A. The jet condenser receives its supply from the overflow, from the gravity tank, or from the condensate pump direct, while the surface condenser receives its supply from the supply furnished to the main condenser.

Q. State the different methods of measuring a vacuum.

A. By mercury column, vacuum gauge and thermometer.

Q. Which is the most accurate method?

A. The thermometer, then refer to vacuum at that temperature.

Q. Why?

A. Because the chance of error is slight if the thermometer is read correctly, due to the fact that no corrections are necessary as in the case where a mercury column is used.

Q. Assuming a case where the supply of steam is not continuous and the amount of cooling water unlimited at 70 degrees F., what is the highest vacuum obtainable?

A. The vacuum corresponding to 70 degrees F. temperature or a 29.261" vacuum (referred to a 30" barometer).

Q. In the above case what is the absolute pressure corresponding to the vacuum?

A. 0.74 absolute pressure in inches of *mercury,* or 0.363 pounds per square inch.

Q. Assuming an ideal condenser, what does the best vacuum obtainable depend upon?

A. The temperature of the circulating water.

Q. Assuming a condenser free from leaks and an air pump of sufficient capacity, what is the temperature at the air pump suction?

A. The temperature of the vacuum.

FOR REFERENCE

The following steam table will assist engineers in computing vacuum where thermometer is used in exhaust:

Properties of Saturated Steam from 90-140 Degrees F.

Tem'ture Degrees F.	Vacuum in Inches	Tem'ture Degrees F.	Vacuum in Inches
90	28.58	116	26.92
91	28.53	117	26.83
92	28.49	118	26.74
93	28.44	119	26.65
94	28.39	120	26.56
95	28.34	121	26.46
96	28.29	122	26.36
97	28.24	123	26.26
98	28.18	124	26.15
99	28.13	125	26.05
100	28.07	126	25.94
101	28.01	127	25.83
102	27.95	128	25.71
103	27.89	129	25.60
104	27.82	130	25.48
105	27.76	131	25.36
106	27.69	132	25.24
107	27.62	133	25.11
108	27.55	134	24.98
109	27.48	135	24.84
110	27.41	136	24.71
111	27.33	137	24.57
112	27.26	138	24.42
113	27.17	139	24.27
114	27.09	140	24.12
115	27.01		

Too much attention cannot be paid to the vacuum in turbine operation. It is for this reason that the above tables are given; to interest the marine engineer in the proper manner of computing vacuum. A careful study of the problems given and practiced, both on shipboard with regular sea conditions and with this table, will soon enable the engineer, if he does not already understand this manner of vacuum computation, to compute the vacuum properly.

Questions and Answers On Reduction Gears.

Q. Why must the pinion in a reduction gear be free to move endwise?

A. So that the load can be evenly divided between the two, right hand and left hand, tooth faces. The main gear can move an amount equal to the clearance in the main thrust bearing. The pinion must be free therefore to move with the main gear wheel, otherwise the whole of the propeller thrust and all the tooth pressure would be forced on one tooth face. Not only would the turbine thrust be overloaded and in danger but the entire pressure would be on one helix only.

Q. What is meant by the " viscosity " of oil and how is it measured?

A. " Viscosity " means body or thickness. " Saybolt " viscosity is the standard most generally used in this country and is expressed as so many seconds at some given temperature in degrees Fahrenheit.

Q. What type of oil should be used in a vessel driven by geared turbines and what viscosity should be demanded?

A. Pure mineral oil that is not compounded and one that water will break from freely should there be a mixture. The viscosity should be about 350 seconds at 100 degrees F.

Q. If the oil supply fails what will happen to gear teeth and to bearings?

A. The tooth surfaces will gall and score and the bearings will wipe.

Q. Why should the oil be kept below the level of the gear wheels in the drain tank?

A. To prevent the gears from splashing and whipping up the oil thereby increasing its temperature and reducing its efficiency.

Q. What clearance should these high speed bearings have?

A. Generally 2/1000 of an inch per inch of diameter of the bearing. This has been found to be good practice though some manufacturers and most engineers have other methods by which they gauge clearance in bearings. The clearance mentioned above allows free passage of oil and also allows an oil film to form upon which the pinion or the spindle, as the case may be, floats.

Q. How often should oil strainers be examined?

A. As often as is possible. When the ship is new and has just been delivered from the builders it is best to examine and clean the strainers at least once each hour. It is best to pay a little overtime for this purpose than to have to be towed into port with a wrecked turbine or gears. As the oil begins to clean up and the strainers do not catch so much foreign matter the clearing period can be made once each watch, but at no time should this period ever be changed afterward. New oil is being put into the system now and then and though the utmost care may be taken, dirt and chips of wood will find its way into the pipes.

Just an afterword. Ordinary common sense and care is all that is necessary for the marine engineer to use to operate a turbine. He already has the training of the sea which makes him resourceful and he understands the principles which the turbine operates under. Each voyage he will discover details which will make him more sure of his ground, each time he sets forth and in a short time he will note that the turbine is running better, or so it seems to him, while the real reason is that he is beginning to understand it better.

There is nothing mysterious about the propelling equipment of a geared turbine driven ship. In fact marine men are beginning to like them better as they know them better and it does seem that the marine engineer would soon recognize the value of the turbine as has his brother engineer in stationary plants.

Two words should be burned indelibly into every operating engineer's brain; **oil, vacuum,** and two sentences should be framed and displayed *in* every engine room: **Don't lose the *oil, and* Watch the vacuum.**

ELECTRICAL QUESTIONS AND ANSWERS

Q. What is a Volt?

A. A Volt is the practical unit of electromotive force or pressure.

Q. What is an Ohm?

A. An Ohm is the practical unit of resistance.

Q. What is an Ampere?

A. An Amphere is the electrical unit denoting the rate of flow of an electric current, or the strength of an electric current.

Q. What is a Watt?

A. A Watt is the electrical unit of power. The power in Watts is equal to the strength of current in amperes multiplied by the electromotive force in volts.

Q. What is a Killowat?

A. A Killowat is 1000 Watts, or 1⅓ horse power. Electrical units are rated in Watts.

Q. What is meant by direct current?

A. Direct current is one flowing in one direction.

Q. What is meant by alternating current?

A. Alternating current is one which reverses its direction in a periodic manner, rising from zero to maximum strength, returning to zero and then going though similar variations in strength in the opposite direction. These changes comprise the cycle which is repeated with great rapidity. Frequency represents the number of cycles per second.

Q. What two kinds of windings are used in Armatures?

A. The series and the parallel winding.

USEFUL INFORMATION

To find the diameter of a circle, multiply circumference by .31831.

To find circumference of a circle, multiply diameter by 3.1416.

To find area of a circle, multiply square of diameter by .7854.

To find surface of a ball, multiply square of diameter by 3.1416.

To find cubic inches in a ball, multiply cube of diameter by .5236.

Doubling the diameter of a pipe, increases its capacity four times.

Double riveting is from sixteen to twenty per cent. stronger than single.

One cubic foot of anthracite coal weighs 53 pounds.

One cubic foot of bituminous coal weighs from 47 to 50 pounds.

One ton of coal is equivalent to a cord of wood for steam.

There are nine square feet of heating surface to each square foot of grate surface.

About four thousand pounds of wood are equal to one ton of soft coal for steam purposes.

The average consumption of coal for steam boilers, is 12 pounds per hour for each square foot of grate surface.

A horse power is equivalent to raising 33,000 pounds one foot per minute, or 550 pounds one foot per second.

A cubic foot of iron weighs 486.6 pounds.

A square foot of one-half inch boiler plate weighs twenty pounds.

Coal consists of—carbon, hydrogen, nitrogen, sulphur, oxygen and ash. These are found in different proportions in different specimens of coal.

Atmospheric air must be mixed with coal before it burns.

In calculating horse power of tubular or flue boilers, consider fifteen square feet of heating surface equivalent to one nominal horse power.

Each nominal horse power of a boiler requires thirty to thirty-five pounds of water *per hour.*

Pure water is composed of hydrogen and oxygen in proportion of two parts hydrogen to one part oxygen, chemically known at H_2O. Oxygen is much heavier than hydrogen, so that water contains 87 parts oxygen and 11 parts hydrogen.

The units of volume employed in measuring water are the cube and gallon. For all practical purposes the following tables are used:

1 cubic foot equals 7.481 gallons.
1 gallon equals 0.1337 cubic feet.
1 cubic foot weighs 62.5 pounds.
1 gallon weighs 8.355 pounds.

The weight of water per unit of volume depends upon its degree of purity and its temperature.

The weight of a cubic foot of water is the greatest at the temperature of 39.2 and the least at the boiling point, 212° F.

Water freezes at 32° F. It contracts as the temperature decreases until it reaches 39.2° F. When it turns to ice it expands about one-eleventh of its volume. This is why pipes burst when ice is formed in them, and it is also why ice floats in water.

To evaporate one cubic foot of water, requires the consumption of seven and one-half *pounds of* ordinary coal or about one pound of *coal to one* gallon of water.

One gallon of water U. S. standard weighs 8½ pounds and contains 231 cubic inches.

Steam rising from water at its boiling point 212° F. has a pressure equal to the atmosphere—14.7 pounds to the square inch.

To evaporate one cubic foot of water, requires the consumption of 7½ pounds of ordinary coal or about one pound of coal to one gallon of water.

A cubic inch of water evaporated under ordinary atmospheric pressure, is converted into one cubic foot of steam, approximately.

There are 6,080 feet in a knot and 5,280 feet in a mile.

A fathom is equal to six feet. A nautical mile is equal to 1,014 fathoms.

Iron has the greatest tensile strength at a temperature of about 600°.

A cubic foot of iron weighs 486.6 pounds.

The weight of atmosphere at sea level is 14.7 pounds.

The specific gravity of a substance is the number which expresses the relation between the weights of equal volume of that substance and distilled water at 60° F.

Linking up I.P. increases the power of the I.P. engine and decreases the power of the H.P., the L.P. remaining about the same as before.

Opening out I.P. decreases the power of the I.P. and increases the power of the H.P., the L.P. remaining the same.

Linking up L.P. increases the power of L.P., decreases power of I.P., the H.P. remaining the same.

Opening out L.P. decreases power of L.P. and increases the power of I.P., the H.P. remaining the same.

Linking up the H.P. decreases the power of all engines and opening out H.P. increases the power of all engines.

To find quantity of salt remaining in sea water after evaporation, reduce pounds of sea water to ounces, and divide by 32.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434.

Temperature of water at

100 lbs.	steam	pressure	338	degrees.
150 "	"	"	366	"
180 "	"	"	380	"

Thickness of copper pipe required.

2 in.	requires	.108
2.5 in.	”	.119
3 in.	“	.130
4 in.	“	.153
5 in.	“	.175
8 in.	“	.243
11 in.	“	.310

To find area of piston. Area in square inches:

Diameter in inches × dia. in inches × .7854 = area.

To find piston speed in feet per minute:

$$\frac{\text{Length of stroke in ins.} \times 2}{12} \times \text{no. of revol. per min.}$$

To find diameter of cylinder for given horse power:

$$\text{Square root of } \frac{33{,}000 \times \text{h. p.}}{\text{piston speed} \times \text{mean effective press.}} \div .7854 = \text{Diam.}$$

Given revolutions and piston speed, to find length of stroke:

$$\frac{\text{Piston speed in feet per minute}}{\text{Revolutions} \times 2} = \text{stroke in feet.}$$

Given length of stroke and piston speed, to find revolutions:

$$\frac{\text{Piston speed in feet per minute}}{\text{Length of stroke in feet} \times 2} = \text{Revolutions}$$

Length of stroke in in. ÷ 2 = length of crank in *inches.*

Length of crank in feet×4=piston travel for one revol.

Length of stroke in feet÷2=piston travel for one revol.

To find the pressure of steam in an engine cylinder at given point in the stroke:

$$\frac{\text{Pressure}\times\text{length of stroke to cut off}}{\text{Desired point in stroke}}=\text{Stm.Pres.}$$

Point of cut-off to obtain limit of expansion:

$$\frac{\text{Back pressure}+\text{friction}\times\text{stroke in feet}}{\text{Initial pressure per square inch}}=\text{Limit}$$

To obtain actual ratio of expansion:

$$\frac{\text{Length of stroke in inches }+\text{clearance in inches}}{\text{Lgth. of stroke to point of cut-off}+\text{clrnce.in in.}}$$

Point of cut-off to produce given ratio of expansion:

$$\frac{\text{Length of stroke in inches}+\text{clearance in inches}}{\text{Actual ratio or expansion}-\text{clearance in inches}}$$

When placing engine on the dead center for the purpose of adjusting valves, as increasing or diminishing the lead, always have the engine on the *exact* dead-center.

Lap. Steam The amount the ends of a valve *lap or extend* beyond the outer edge of steam port, when valve is placed centrally over the ports.

Lap. Exhaust. The amount the valve extends beyond the inner edge of steam port, when valve is placed centrally over the ports.

Valve Travel. The distance the valve moves during one full stroke, or the distance it moves during one-half revolution of eccentric, viz., from one dead-center to the other.

Throw of an eccentric. Twice the distance from the center of the eccentric to the center of crank shaft, or, the distance an eccentric is capable of moving the valve, without the presence of any multiplying mechanism.

Lead. The amount of port opening, when an engine is on the dead center.

Admission, period of. The distance moved through by the piston, before cut-off takes place.

Cut-off, point of. That point in the stroke at which steam is shut off, or, at which the supply of steam to the cylinder is cut off.

Expansion. The distance the piston moves, after the supply of steam to the cylinder has been cut off and before release takes place.

Release or Exhaust. The point in the stroke at which the exhaust valve opens and releases the steam from the cylinder.

Back Pressure. Pressure of the unexhausted steam in the cylinder, during the return stroke.

Compression, Point of. That point in the return stroke at which the exhaust valve closes and entraps a portion of the exhaust steam, which is compressed into the clearance space.

Automatic Cut-Off. Valve mechanism so arranged that the point of cut-off is changed and controlled by the governor.

Releasing Valve Gear. An arrangement of valve mechanism, whereby the valve is opened by a member of the valve gear, is releasd by the governor at the proper point in the piston stroke and is closed by what is known as the dash pot.

Throttling Engine. An engine, the speed of which is governed by varying the steam pressure the volume or quantity of steam admitted to the cylinder remaining the same.

Automatic Cut-Off Engine. An engine, speed of which is governed by changing the point of cut-off, thus varying the volume or quantity of steam admitted to the cylinder, the steam pressure remaining the same.

Riding Cut-Off. A riding cut-off comprises *two valves,* a main valve and a cut-off valve.

The main valve is provided with ports, which register with the steam ports in the valve seats. The cut-off valve rides or slides on the back of the main valve, closing the ports in the latter, thus cutting off the supply of steam to the cylinder. A riding cut-off may be made positive, adjustable or automatic.

To find the surface in square feet in any size pipe:

$$\frac{\text{Diameter in ins.} \times 3.1416 \times \text{length in ins.}}{144} = \text{sq. ft.}$$

Temperatures Fahrenheit and Centigrade:

Given degrees Fahrenheit to find degrees Centigrade.

$$\frac{\text{Degrees F.} - 32 \times 5}{9} = \text{Centigrade.}$$

Given degrees Centigrade to find degrees Fahrenheit.

$$\frac{\text{Degrees Centrigrade} \times 9}{5} = \text{F.}$$

One horse power equals 550 pounds raised one foot per second.

One horse power equals .70694 heat units.

One foot of sea water equals 1.026 feet of *pure water.*

To find the volume of water cylinder in cubic inches:

Diameter in inches×diameter in in.×.7854× length of stroke in inches.

To find discharge of a pump in gallons:

$$\frac{\text{Vol. of water cyl. in ins.}\times\text{no. of strokes per min.}}{\text{231 cu. inches}}$$

Given the volume of cylinder in cubic inches and diameter to find length of stroke of piston:

$$\frac{\text{Volume of pump cylinder in cubic inches}}{\text{Diameter in in.}\times\text{diameter in in.}\times.7854}=\text{Ans.}$$

To find the height of a column of water:

Pressure in pounds per sq. inch÷.434=Height

To find quantity of steam used at each stroke:

$$\frac{\text{Area of piston in sq. in.}\times 6\times .166}{\text{Cut-off in decimal parts of stroke}}=\text{cu.in.of stm.}$$

To find weight of steam consumed per H.P. per hour:

$$\frac{34}{\text{Absolute mean pressure}\div\text{absolute terml. press.}}$$

Average back-pressure pressure-mean effective pressure.

Initial pressure is the pressure in the cylinder at the beginning of the stroke.

Terminal pressure is the pressure in the cylinder when exhaust takes place.

The temperature of steam in contact with water, depends upon the pressure under which it is generated. At ordinary atmospheric pressure (14.7 lbs. per sq. in.) its temperature is 212° F. As the pressure is increased, as by the steam being generated in a closed vessel, its temperature and that of the water in its presence, increases.

Saturated steam is steam of the temperature due to its pressure — not superheated.

Superheated steam is steam heated to a temperature above that due to its pressure.

Dry Steam is steam which contains no moisture. It may be either saturated or superheated.

Wet Steam contains intermingled moisture, mist or spray. It has the same temperature as dry saturated steam of same pressure.

Gaseous Steam — When saturated steam is superheated or subcharged with heat, it advances from the state of saturation to that of gaseity. The gaseous state is only arrived at by considerably elevating the temperature, supposing the pressure remains the same. Steam thus sufficiently superheated, is known as *gaseous steam* or steam gas.

Weight of coal burned=4,000 lbs.; weight of ash removed=480 lbs., what is the percentage of ash per ton coal burned?

Weight of ashes in pounds divided by number of tons of coal, equals weight of ash for one ton. Weight of ashes in pounds divided by weight of coal burned in pounds=percentage per ton:

480÷2 ton=240 weight of ash per ton.
480÷4000 lbs.=12% per ton.

To find the length or depth of a cylinder to contain a given number of cubic inches, the area being given:

$$\frac{\text{No. of cubic inches}}{\text{Area in sq. inches}} = \text{depth or length in inches.}$$

To find the area of the surface of a sphere:

Diam. × diam. × 3.1416=surface.

To find the volume of a sphere —

Diam. × diam. × diam. × .5236 = Vol.

To find the volume of water in pounds contained in given volume of steam:

Volume of steam in cubic feet × density corresponding to pressure = pounds.

To find the percentage of gain by heating feed water.

$$\frac{\text{Temperature of water entering boiler—temperature of water entering heater.}}{\text{Total heat units in water above } 32° + 32 \text{—temp. of water entering heater.}}$$

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